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THE TRUSTEES OF THE BROOKLYN BRIDGE have received the report of the board of expert engineers appointed to investigate the question of the feasibility of running through cars from the Brooklyn elevated and electric railways across the bridge. The report is favorable to this through traffic as increasing the facilities for the large proportion of passengers who go to and from the bridge by the cars of the elevated or surface railways. According to the plans submitted by the committee the surface railways will have a single track on each of the present roadways. At the Brooklyn end all westbound cars will go down Washington St. to the roadway for westbound traffic, and all eastbound cars on the other roadway will turn into Fulton St. By this arrangement of tracks the vehicles using the roadways will not have to cross any car tracks at the bridge entrance. At the New York end will be a loop terminal, with sidings for the cars of the various routes. Cars will stop on the sidings to load and unload (the platforms being at about the same level as the present platforms for the bridge cars) and will then continue on from the siding onto the main track and around a loop to the other side of the station. These tracks in the station will be over the present roadways, the sides of the station being moved out to widen the building. For the elevated railways, two of the four tracks at each station and one of the two stub switching tracks at the New York end will be given up to the through trains. At the Brooklyn end the Brooklyn Elevated R. R. will connect with the Kings County Elevated R. R., and all trains will use the Fulton St. line of the latter road, turning off at Tillary St., and having one track on each side of the elevated yards of the bridge railway, thus avoiding all interference with the yards. The cars of the elevated railways will have cable grips and side doors, and one car of each train will have electric motors for switching at the terminals. The locomotives will be cut off at the yards, and the bridge authorities will assume responsibility for the trains, their own employees handling all trains across the structure. It is estimated that there will be one local bridge train to three elevated railway trains, as most of the traffic would consist of through passengers. The report was referred to a committee of three of the Trustees, who will report upon it next week. We have steadily advocated the provision for through traffic, as stated in the editorial in our issue of Jan. 7, and next week we shall present the plans as recommended by the board of experts. This board was composed of Messrs. Virgil G. Bogue, L. L. Buck and George H. Thompson, all members of the American Society of Civil Engineers.

TWO COMPRESSED AIR CARS of the American Air Power Co. were given a trial run in New York last week, the trip being from Fort Lee ferry to Broadway and the Grand Central Station. The cars carry air at 2,000 lbs. pressure in the reservoirs.

THE PARK AVE. VIADUCT and the high-level four-track drawbridge of the New York Central R. R., in New York city, are to be put in service this week. The work was commenced in July, 1892, but has been delayed by litigation. The new line commences at the mouth of the tunnel at 96th St., from which point the grade rises to the higher level, which is continued to and beyond the Harlem River, falling then to the present grade, about 2½ miles from the tunnel. The heavy steel viaduct and the great drawbridge have been described in our columns. The total cost of the work is about $1,800,000, of which the city has paid $760,000, and the New York Central R. R. has paid $1,040,000.

THE UNDERGROUND ELECTRIC TROLLEY SYSTEM has been adopted by the Metropolitan Traction Co., of New York city, for the Sixth, Eighth and Amsterdam Ave. lines on the west side, the Fourth and Madison Ave. lines on the east side, and the 59th St. crosstown line. Contracts have been let for the electrical machinery and equipment, and work on the conduits will be commenced as soon as the weather is suitable. The system will be that of the General Electric Co., now in operation on the Lenox Ave. line.

AN INTERESTING FRANCHISE has just been granted in Chicago to the General Electric Street Railway Co. The franchise is reported as being limited to 20 years, and as being for 25 miles of streets, including 42 blocks on Wabash Ave. It appears that Mayor Swift was not satisfied with the ordinance granting the franchise, as passed by the city council, and proposed to veto it. To prevent this, the company agreed to enter into a supplemental contract, providing for an underground system, improved grooved rails, shelter for motormen, a full transfer system, trains with over two cars in length and compensation to the city for each five-year period as follows: first five years, none; second, 5% of the gross receipts; third, 7%; fourth, 10%. The contract was ratified by the council by a vote of 60 to 6.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision at Arlington, S. Dak., on the Chicago & Northwestern Ry., Feb. 3. The front train should have taken the sidetrack, but the switch was clogged with ice, and before it could be cleaned the following train came up. Four persons were killed and several injured.——A trestle on the Cumberland & Pennsylvania R. R., at Franklin Mines, Md., gave way under a passenger train Feb. 7. The engine crossed in safety, but the combination car and baggage car went down. The engineman and fireman jumped and the former was killed. All the passengers escaped without serious injury. One of the bents of the trestle had been washed out.

A HEAD COLLISION OF ELECTRIC CARS occurred in Abington, Mass., Feb. 3. Owing to a blinding snowstorm the motormen were unable to see each other till 100 ft. apart, and could not stop the cars because of the steep grade. One mortorman was fatally injured and the other had his jaw broken. No passengers were injured.

A GAS EXPLOSION occurred Feb. 6 on the East River ferryboat "Columbia," running between Grand St., New York, and Broadway, Brooklyn. Owing to an accident to the dynamo, the boat was being lighted temporarily by gas, and at the time of the explosion, the reservoir or tank on the vessel was being charged with gas from the mains by means of a hose coupling. Nobody was badly hurt. The tank is reported to have been a collapsible or bellows arrangement, 6 ft. diameter, and with such a tank it is quite likely that air may have leaked in.

THE BROKEN FLYWHEEL of a rope-driving plant operated by hydraulic power at the works of the People's Power Co., Moline, Ill., on Feb. 3, caused considerable damage to the ropes and gearing.

SANDING ASPHALT PAVEMENTS is to be tried in New York, by the Department of Public Works, as a means of counteracting their slippery tendencies when coated with ice. One cause of trouble in this city is that asphalt pavements have been frequently laid over those of Belgian block without reducing the extreme crown of the old pavements. The result is an undue rounding of the street surface.

THE METER QUESTION is now up for an airing in Brooklyn, in connection with a new water supply. Mr. Peter Milne, Chief Engineer of the Department of Public Works, has been interviewed on the subject, and is reported as saying that the daily consumption might be reduced from 80 to 60 gallons per capita, or as many millions in the aggregate, by the use of meters. Mr. I. M. de Varona, M. Am. Soc. C. E., Chief Engineer of the Water Bureau, has just submitted a report on the meter question to a committee of the Manufacturers' Association of Kings and Queens Counties. He states that on Jan. 1, 1896, there were in use in Brooklyn 103,222 taps, of which only 2,495 were metered. He cited instances of the beneficial results from the use of meters in other cities, and stated that the adoption of meters is the way, not only to avoid waste, but of properly distributing the cost of supplying water. Both Mr. Milne and Mr. De Varona estimate that it would cost some $2,000,000 to meter the whole city, and Mr. Milne is represented in his interview as questioning the wisdom of such a course, although admitting the value of meters. Col. Geo. E. Waring, Jr., M. Inst. C. E., has an article in a recent number of "Harper's Weekly" in which he points out how Brooklyn might with advantage adopt the meter system, giving many apt illustrations to enforce his points. This article, we presume, is largely responsible for the meter agitation in Brooklyn.

ANOTHER NEW WATER SUPPLY BILL for Philadelphia has been introduced in the select council. It provides for a maximum daily supply of 300,000,000 gallons delivered to the city for $900,000 per year, and $1.85 additional for each 1,000,000 gallons filtered.

A NEW WATER SUPPLY FOR CINCINNATI is now a possibility, the State Supreme Court having declared constitutional all but one section of the act passed last year authorizing $6,500,000 of bonds for works and providing for a commission to construct them. The section condemned by the court was one providing that the commission might, if it chose, contract with a construction company to build the works and to operate them for 40 years, with the privilege of renewing the lease. The commission was appointed by the mayor some months ago, as follows: August Herrman, Dr. Graydon, Leopold Markbreit, Capt. C. M. Holloway and Maurice Freiberg. The commission is empowered to let contracts for the works in the ordinary way, but the interest and bond payments must be met from the revenue of the water department.

THE OWNERSHIP OF GROUND WATER IN COLORADO does not pertain to the land, according to recent court decision, when it can be shown that the water goes to increase the flow of water in a stream, the waters of which have been appropriated previously.

A TEMPORARY INJUNCTION against the use of Jewell filters, at Elmira, N. Y., in such a manner as to infringe upon the Hyatt patent, No. 293,740, has been issued against the Elmira Water-Works Co. and the Morison-Jewell Filtration Co., by Judge Coxe, of the U. S. Circuit Court for the Northern District of New York. The hearing on the application for a permanent injunction has been set for Feb. 16. The suit was brought by the New York Filter Manufacturing Co., which controls the Hyatt patent. The patent involves the use of alum in mechanical filters, without the intervention of settling or precipitating tanks. The above information is given on the authority of the New York Filter Manufacturing Co. The Elmira filter plant has just been constructed, with a daily capacity of 6,000,000 gallons, but has not been put in operation.

A BILL TO PROTECT THE PURITY of inland waters has been introduced in the Pennsylvania legislature. It gives the State Board of Health oversight of the general of the matter and provides for consultation with board by the proper officials before constructing local water and sewerage systems.

CIVIL SERVICE EXAMINATIONS will be held as follows by the New York City Civil Service Commission, and particulars can be obtained from Mr. S. William Briscoe, Secretary of the Commission, New Criminal Court Building, New York city: Building superintendent, Fire Department, Feb. 16; building inspectors of masonry and construction other than iron and steel, Feb. 17; bridge engineers and draftsmen, Feb. 18; chainmen and rodmen, Feb. 23. Applications are desired for the positions of building inspectors of carpentry, of masonry and of iron and steel construction; also inspector of light, plumbing and ventilation, and instrument maker.——Civil service examinations will be held as follows by the City Civil Service Commission of Brooklyn, N. Y., at its office in the city hall: Assistant bacteriologist, March 22; draftsmen and assistant draftsman, March 25; leveler, April 4.

THE STATE ENGINEER OF NEW YORK, Mr. Campbell W. Adams, has just presented his annual report. He recommends that the Erie Canal deepening now under way should be made for 9 ft. of depth instead of 8 ft. and that changes be made in the lock gates of the present lengthened locks so that the boats can be increased from 98 ft. to 115 ft. in length. This would enable the maximum boat load to be increased to 410 tons instead of 300 tons at present. He also favors such improvements in lock handling and towing apparatus as will enable the larger boats to make the trip in no longer time than at present. The surveys are completed for the entire improvement under the "nine million dollar act;" and contracts for work estimated at $3,410,972 have been awarded at an aggregate price $382,247 less than the engineers' estimates. The plans have been completed and accepted for a lift lock on the pneumatic principle at Lockport, contracts will be let for it early in the spring, and it is to be completed ready for use when navigation opens in 1898. Mr. Adams regards the organization of the Consolidated Lake & Canal Co. as a most important and beneficial movement, and likely to have great influence in bringing traffic back to the canal. The state is spending its millions on the canals, not solely in the interests of a few hundred boat owners but to protect the business interests and increase the wealth of the entire state.

COAL HANDLING PLANT OF COXE BROS. & CO., CLYBOURNE AVE. DOCKS, CHICAGO, ILL.

An anthracite coal handling and storage plant for which great efficiency of operation is claimed has recently been built by Coxe Bros. & Co., at Clybourne Ave., on the north branch of the Chicago River at Chicago, Ill. This plant receives coal, which is carried by rail from the company's Pennsylvania mines to Buffalo, N. Y., and thence

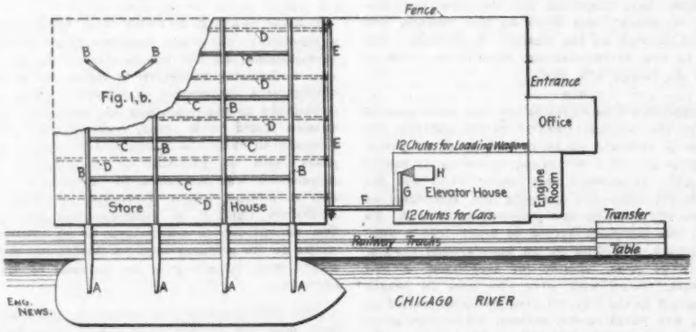


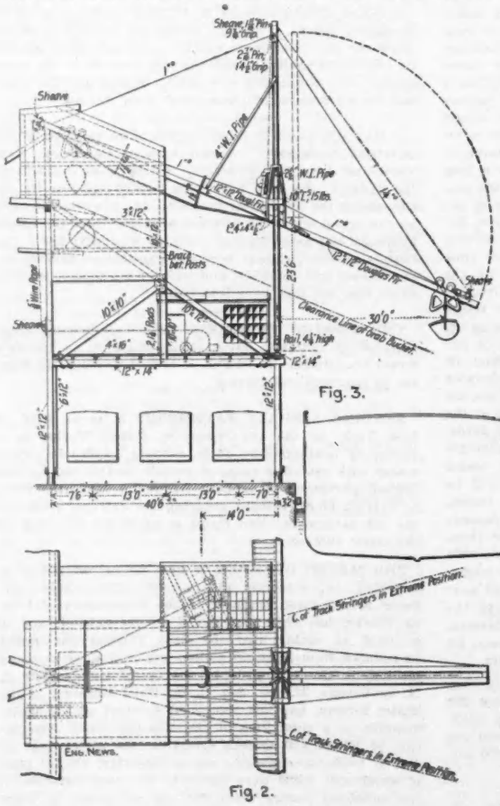
FIG. 1—SKETCH PLAN OF COAL STORAGE AND HANDLING PLANT OF COXE BROS. & CO., CLYBOURNE AVE. DOCKS, CHICAGO, ILL.

by boat to Chicago, and unloads, stores, elevates and separates it for shipment and for sale to the city trade. As an example of the thoroughness with which machinery is applied to the handling of coal in modern practice, the Clybourne Ave. plant is particularly interesting to engineers. From information furnished by the owners and by the manufacturers who designed and constructed the principal hoists and conveyors, and also through a personal examination by one of the editors of this journal, we are able to give a description of the more notable conveying machinery and its construction and operation.

In Fig. 1 is shown a rough sketch plan of the Clybourne Ave. docks and the coal handling plant. It will be seen that coal is received by boat and is unloaded by means of four conveyors, A, and deposited into hoppers just beneath the roof. From these hoppers it is taken by means of the overhead conveyors, B, which feed into the troughs C. Of course the coal as received and deposited is more or less broken, and to make it ready for sale it has to be separated into proper sizes and stored. This is done in the elevator building. From the storehouse the five horizontal conveyors D, deposit the coal into the horizontal conveyors E and F, and from F the elevating conveyor G takes it to the top of the elevator and discharges it into the "gyrator" H. This "gyrator" is the well-known gyratory screen designed and patented by the late Eckley B. Coxe, M. Am. Soc. C. E., and it separates or screens the coal into seven sizes and feeds each size into the proper hoppers in the elevator house. From these hoppers the coal is delivered into cars or into the city dealer's coal wagons as indicated.

Turning now to a more special consideration of the conveying machinery, the first in order of employment are the four hoists used in unloading the coal. These were designed and built by the Brown Hoisting & Conveying Machine Co., of Cleveland, O., and embody all the patents and improvements controlled by that firm. Figs. 2, 3, and 4 show in some detail the construction and operation of these hoists, Fig. 2 being a plan, and Figs. 3 and 4 side and end elevations respectively. It will be seen that each consists of a vertical A-frame carried on wheels so as to allow of a horizontal travel of 10½ ft. in either direction from the normal center position. The legs of this A-frame are rectangular columns composed of four steel angles latticed together, and the horizontal brace at the bottom is a steel plate box-girder. This A-frame carries the inclined track on which the carriage runs, and the carriage and bucket are operated by means of the hoisting engine and a single wire rope, clearly shown by the drawing. All the general structural details of the conveyor are also fully shown by the drawings and need not be described further.

It will be seen from the illustrations that the four conveyors are placed 40 ft. apart c. to c. on a platform extending over the railway tracks so that the apron of the carriage track projects out over the water to beyond the middle line of any ordinary coal steamer or barge. All four or any one of the conveyors can be used at the same time as each is an independent machine, and when not in use the portion of the carriage track extending out beyond the edge of the dock, or the "apron," can be raised to a vertical position clear of the vessel's rigging and out of the way of other work. The present method of raising this apron is by a hand winch, but the design intended the use of power, and power apparatus will be added in the near future. In Fig. 5 is given a view of the four conveyors, with the aprons raised, which indicates very clearly their general location and arrangement. Attention should perhaps be called again to the provision for side adjustment by means of the wheels on the A-frame, and to the fact that the bucket is automatically self-dumping and requires no attendance, except to fill and lock it when it reaches the hold. Provision is, of course, made for locking the wheels of the A-frame at any position so as to prevent undesired movement. It is to be noted also that these conveyors simply raise and convey the coal to the pockets, on the river side of the storehouse.



FIGS. 2, 3 AND 4.—DETAILS OF BROWN CANTILEVER CONVEYORS FOR HANDLING COAL, CLYBOURNE AVE. COAL DOCKS.

Brown Hoisting & Conveying Machine Co., Cleveland, O., Builders.

As indicating the capacity of the conveyors in actual work, the following records have been furnished by Coxe Bros. & Co., but as a matter of fact the possible capacity is limited by the rapidity with which the buckets can be loaded. The records furnished were made with four men loading each bucket and were ordinary runs without any special attempt to show large results. They are: From steamer "H. E. Runnels," 1,232 tons in 8½ hours with three conveyors; from steamer "Emery Owen," 2,001 tons in 16½ hours with three conveyors; from barge "Mary E. McLachlin," 2,464 tons in 16 hours with four conveyors. The capacity per hour per conveyor in these three cases were thus, 48.3 tons, 41.7 tons, and 38.5 tons, respectively, which may be accepted as a good average showing of what the machine can do. As the capacity of the bucket is one ton, the number of trips per hour is readily calculated. Each machine requires an operator in its engine house.

These cantilever conveyors and their equipment and the transfer table and some other details were designed and installed by the Brown Hoisting & Conveying Machine Co., as previously stated, but the other conveying machinery was built after designs and patents of the Link-Belt Machinery Co., of Chicago, Ill., the Jeffrey Mfg. Co., of Columbus, O., and Coxe Bros. & Co. Considering these various conveyors in order it will be noted that from the four hoppers the coal is delivered to four chain conveyors B. These conveyors are about 7 ft. below the roof, so that headroom is allowed for a foot-walk alongside of each, and they extend the full depth of the building, 180 ft. The chain used is the "Monobar," of the Link-Belt Machinery Co., with 8 × 10-in. steel flights or scrapers attached at intervals of 2 ft. To the top of each scraper is fastened a steel cross bar with cast-iron sliding shoes at each end. These shoes slide on lubricated angle runways so that the scrapers are held off the bottom of the trough, thus reducing the noise and wear, and decreasing the amount of hauling power required. The accompanying sketch (Fig. 6) shows a short section of one of these conveyors as it appears loaded and unloaded, and explains its general construction quite clearly.

At convenient intervals along the conveyor troughs B are valves or discharge gates in the bottom of the trough which are operated from the

foot-walks by a rack and pinion and hand wheel apparatus. Beneath these gates are the chutes C, which are shallow troughs looping down as shown at Fig. 1b. The object of the loop is to enable the coal to be discharged onto the storehouse floor with a minimum fall at all times to prevent breakage as far as possible. Each of the four distributing conveyors, B, is driven by a set of equalizing gears,

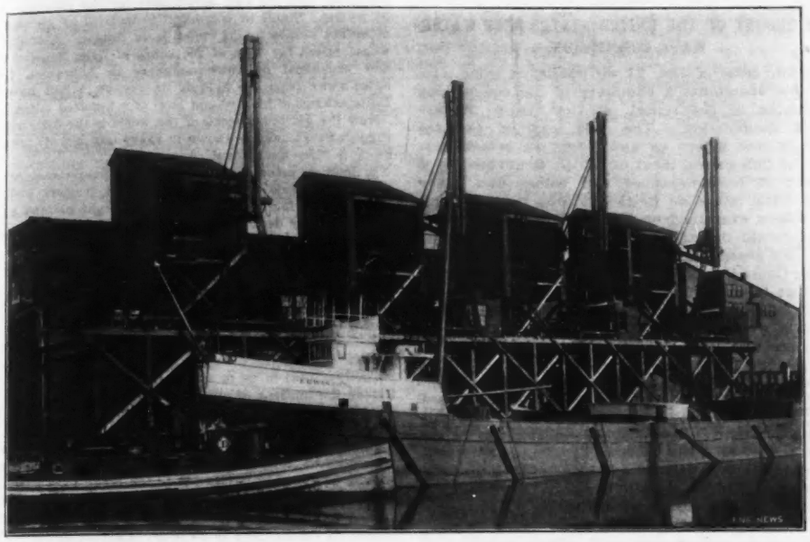


FIG. 5.—RIVER FRONT OF CLYBOURNE AVE. COAL DOCKS SHOWING CONVEYORS WITH APRONS RAISED.

operated by pinions on a line shaft running the length of the storehouse at right angles to the conveyors. This line shaft is operated by an engine placed just below the roof and supported and enclosed by a substantial tower. The pinions are provided with friction clutches so that any of the conveyors can be thrown in or out of operation at will, though the engine and driving machinery are of ample capacity to operate all of the conveyors at one time.

It will be seen from the foregoing, that the chutes C distribute the coal pretty evenly over the storehouse floor. Ordinarily the storehouse holds 35,000 tons, but it can be crowded to hold 40,000 tons. To take the stored coal to the elevator house there are five conveyors D, running lengthwise of

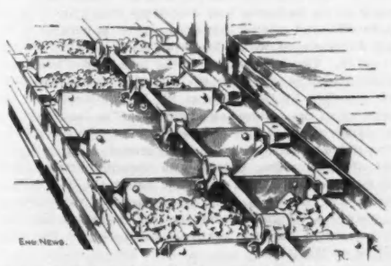


Fig. 6.—Sketch of "Monobar" Chain Conveyor, Clybourne Ave. Coal Docks.

the shed, each of which is something over 200 ft. in length. These, of course, are buried beneath the coal, from which they are protected by substantial wooden tunnels. At intervals in the sides of these tunnels are cast-iron gates of special form, through which the coal is allowed to flow into the conveyors as needed. These gates are all attached by cables to levers at the front end of the shed, near the head end of the conveyors, where they are operated. The operator, standing at the delivery end of the conveyors, can always see the amount of coal handled, and regulate the supply by a greater or less opening of the gate. The levers are provided with trigger and notched arc, so that the gates can be held at just the right height to properly supply the conveyors.

These conveyors on the ground are driven similarly to those above, by equalizing gears and friction clutch pinions on a line shaft, but only three of them are of the Monobar type. These are provided with 6 × 16-in. scrapers, and all deliver into a Monobar conveyor E, running at right angles. This conveyor is of sufficient size to carry away all that two of the conveyors D can bring to it, and delivers into an inclined double-strand Monobar conveyor with 38-in. flights, which takes the coal over beneath the elevator house and discharges into the boot of a "Gravity-Discharge Elevator," a type of elevator especially designed by the Link-Belt Machinery Co. for the late Eckley B. Coxe, to reduce breakage to a minimum. Fig. 7 is a sketch of this elevator in operation.

The conveyors are all run at a speed of about 75 ft. per minute, at which speed the overhead conveyors have a normal capacity of 90 tons an hour each, the conveyors on floor of shed 45 tons per hour each, and the cross-conveyors E and F, 90 tons per hour. For driving the four upper conveyors B, a 35-HP. engine is provided. The lower conveyors are driven by the main engine of the plant. An interesting and valuable feature of the conveyor system is a safety device which immediately stops the engine in case of accident. One of these devices is placed at each engine, and connected by wires with the conveyors operated by the particular engine; the wires being so arranged that in case of accident to the conveyor they release a weight which throws the governor belt off the engine.

The Monobar chain, to which reference has been made as being used throughout this system of conveyors, is decidedly unique, being broadly described as a series of bolts flexibly connected. The connections are made of malleable iron and the resulting chain thus has large bearing or articulating surfaces, gives the maximum obtainable strength for its weight, and offers no opening or surface for the coal to lodge on. The illustration (Fig. 6) gives a good idea of the general appearance of the chain, which is made of varying diameters of bolt, and length of pitch, that used throughout this plant having a bolt 1¼ ins. diameter and 24-in. pitch. It will readily be seen that the use of a chain of so long pitch is a very important element in reducing its weight while maintaining the strength, but the use of such long pitch chains is only practicable with equalizing gears, to which previous reference has been made, and of which a drawing is shown by Fig. 8, the peculiar form being, for the purposes of clear illustration, considerably exaggerated.

To understand the equalizing gear it is only necessary to remember that a sprocket-wheel revolving at a uniform speed imparts a pulsating or jerky motion to chains of long pitch. The motion is easily understood by referring to the illustration, which shows a seven-sprocket wheel 41½ ins. in diameter in three positions, A, B, and C. As each link engages with the driving sprocket it is first controlled by the radius (A) 20.75 ins. long, and immediately afterwards by the radius (B) 18.69 ins. long. Obviously if the sprocket-wheel is running at ten revolutions per minute, we have a variation of chain speed of 108.64 ft. — 97.86 ft. = 10.78 ft. This variation in speed occurring at intervals of only 43-100 of a second, or 140 times a minute at a speed of chain of 105 ft. per minute, is necessarily fatiguing and destructive to the chain as it produces a violent increase of the normal strain at frequent intervals without any useful result in increasing the capacity of the conveyor. Now the equalizing gears are designed to impart pulsating motion to the driving sprocket-wheel exactly counteracting the variation in chain speed just explained. The object is accomplished by making the pitch diameter of the spur-wheel to conform to a wave-line—the number of elevations and depressions in this line corresponding with the number of sprockets of the chain wheel—and driving the spur-wheel with an eccentric pinion as shown at Fig. 8, C.

As noted above, two of the conveyors D are not of the Monobar type. These were built by the Jeffrey Mfg. Co., of Columbus, O., as was also the elevator house. All the machinery described except the Brown cantilever conveyors, and the four distributing conveyors B, is run by an 80-HP. engine. This engine also runs the transfer table and a cable traction system for moving the cars on the dock tracks. Two 100-HP. tubular boilers furnish the steam for all the engines used; viz.: the main 80-HP. engine, the 35-HP. engine operating the four distributing conveyors B, and the four 10 × 12-in. hoisting engines operating the cantilever conveyors.

Except for such minor apparatus as is too familiar to need description, the foregoing gives a pretty clear understanding of the coal storage plant under consideration. Two general features are to be noted particularly: (1) At no point after being loaded into the buckets of the cantilever

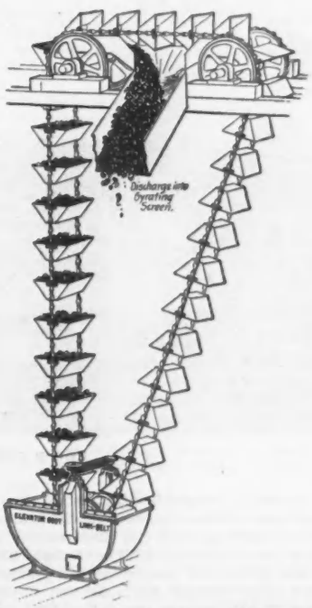


Fig. 7.—Sketch of Gravity Discharge Coal Elevator, Clybourne Ave. Coal Docks.

conveyor in the vessel's hold is the coal moved by hand power until it is unloaded from the wagons or cars to which it is delivered by the elevator-house chutes; (2) At no point after leaving the buckets of the cantilever conveyors is the coal thrown or dropped, but always has a gravity discharge through troughs or chutes. Indeed, this question of breakage, which is an exceedingly important one to large handlers of coal, has been the

subject of most careful study in this plant, and the builders assert that the percentage of loss by breakage is appreciably less here than at any

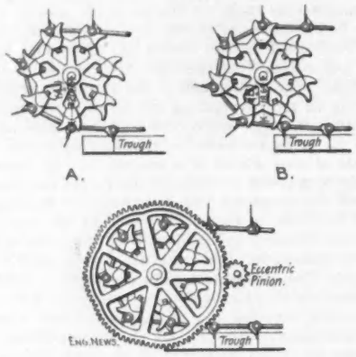
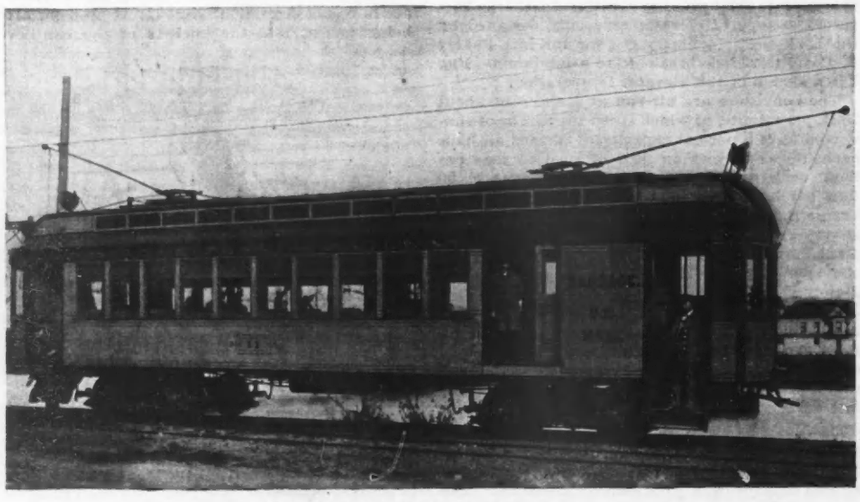


Fig. 8.—Diagram Showing Method of Operation of Equalizing Gears for Chain Conveyors, Clybourne Ave. Coal Docks.

wholesale coal yard in the country. In regard to efficiency, Coxe Bros. & Co. express the opinion that the plant is surpassed by no other similar plant on the Great Lakes.

ELECTRIC MOTOR CAR, CALIFORNIA RY.

The California Ry. is an electric line three miles long, on the east shore of San Francisco Bay, running from a junction with the Southern Pacific Ry. to Leona Heights, and accommodating also Fruitvale and Alameda. Ordinary railway cars are used for the rolling stock equipment. The motor cars, one of which is shown in the accompanying cut, are combination baggage and passenger cars, with vestibuled ends. Each motor car has four General Electric "1,000" motors, automatic circuit breakers and resistances, controller with magnetic blow-out, electric headlights on the platform hoods, an air pump to operate the brakes and two chime whistles, and two trolleys (only one of which is in use at a time). The General Electric Co. will equip another motor car for the railway company's line between Alameda and Fruitvale, using four "2,000" motors instead of four "1,000" motors. The track is similar to that of steam railways, bonded for the return current. The overhead wire is on part of the line suspended from iron brackets on round poles, and on the other part of the line it is suspended from span wires.



MOTOR CAR OF THE CALIFORNIA RY.

CONCEALING A FLAW IN A CASTING sometimes leads to serious results to the makers. In the suit of Brush v. Nashua Iron & Steel Co., a jury gave a verdict for damages of $8,972, against the defendants for injury caused by the failure of a walking-beam on the steamer "Sovereign," of the Ottawa Navigation Co. According to a report of the trial given in the Concord, N. H., "Monitor," the jury was influenced by the production in court of the broken section of the beam, which showed that an ordinary nail had been driven into a fissure in the casting, and its presence concealed by subsequent planing and painting of the surface. Some workman had evidently driven the nail into the flaw, and then finished the piece. The presence of the nail apparently led the jury to decide that reasonable care had not been taken in the production of the beam.

THE REPORT OF THE UNITED STATES DEEP WATERWAYS COMMISSION.

In our issue of Jan. 21 we published from telegraphic dispatches a summary of the conclusions presented in the report of the "Deep Waterways Commission. The full text of the report is now before us and forms an octavo volume of 263 pages, most of which is devoted to a report of reconoissances and tables and other data with reference to the various routes which have been examined on behalf of the Commission to ascertain their feasibility for a ship canal location. We present herewith extracts from those parts of the Commission's report which to us seem of most interest to our readers. We will preface this reprint by saying that the appointment of the Commission was due to a joint resolution adopted by Congress in March, 1895, authorizing the President to appoint three persons:

> Who shall make inquiry and report whether it is feasible to build such canals as shall enable vessels engaged in ocean commerce to pass to and fro between the Great Lakes and the Atlantic Ocean; where such canals can be most conveniently located and the probable cost of the same with estimates in detail.

The persons appointed on this commission were to receive their actual traveling and other necessary expenses, not exceding ten thousand dollars," a pretty small sum to pay for the investigation of an engineering work, which is likely to cost anywhere from 100 to 500 millions. In November, 1895, Hon. Jas. B. Angell, President of the Michigan State University; Mr. John E. Russell, of Massachusetts, and Mr. L. E. Cooley, C. E., of Chicago, were appointed as members of the commission, and in January, 1896, they organized and began work.

We present herewith all that we find in the report bearing on the feasibility of the canal as a commercial enterprise, and as much as space permits of the conclusions as to the relative merits of different proposed routes. In our editorial columns of this issue we have commented on the report.

The most profound economic changes of modern times have been brought about by the improvements in transportation. These began with small canals and later with railroad construction, in the first half of the century, and have proceeded with accelerating speed to the present time.

The railroad of to-day bears about the same relation to the transportation of thirty years ago as that did to the stage coach and freight wagon of the first quarter of the century. The general use of steel has given an efficiency and security to railway traffic far surpassing even the prophesies of enthusiasts. This has been accompanied by the utilization of steel in shipbuilding, which may be said to date from 1878, as in that year less than 2% of steel was used in construction of ships in Great Britain. Minor inventions in the improvement of marine engines and locomotives have accompanied the greater changes and resulted in affecting the living and exchanges of the whole world, and greatly broadening the line of separation between progressive and unprogressive peoples.

In the first half of the century each nation practically depended upon its own agriculture for the subsistence of its people. States or communities isolated by distance or mountain ranges might suffer from famine. A bushel of wheat raised far west of the shore of Lake Superior and now consumed by cotton-spinners in Lancahire, 3,000 miles away from the field of its growth, might have its value exhausted by a wagon haul of a hundred miles.

Now the combined stock of the world is the daily visible supply; its amount is known in every city and its accessibility is fully understood.

In 1869 occurred the opening of the Suez Canal, which brought the East into competition with Western civilization by reducing a voyage of six or eight months to 30 days, virtually destroying the value of the fleet of sailing vessels previously employed, and making it necessary to readjust ancient systems of distribution and all the capital and labor incidental to them.

The agricultural competition we have been compelled to meet from India has lately been intensified by the entrance into the world's market of the rising States of the South of our continent. These circumstances, which will change only in the direction in which they are moving, strongly appeal to us to examine in what manner we can lighten the burdens of our agriculture and keep pace with the world's progress by facilitating and cheapening our internal transportation.

The limit of reduction in railroad freights seems to have been reached; it remains to be determined if it is not possible to extend lake navigation to the ocean by a practicable ship channel, for although the development of our natural waterways is but little advanced beyond the bounty of nature, and is capable of immediate and vast extension, the effect of the little we have done has been enormously profitable.

The chain of great lakes, with a water surface of 95,965 sq. miles, a basin area of 312,365 sq. miles, and coast lines in the United States limits of 3,075 miles, gives us a deep, fresh-water navigation, the extent of which cannot be accurately stated, so rapidly does it increase. If it is over-estimated in enthusiastic estimate, the calm statistics soon overtake the exaggeration.

The coast lines of the lakes border upon nine States, containing more than one-third of our population, and upon their harbors are six cities, with an aggregate population of 3,000,000, and hundreds of rapidly growing towns. The increased power of navigation effected by the Welland Canal, through which vessels of a cargo capacity of 1,700 tons are passed into Lake Ontario and thence to Ogdensburg, a distance from Duluth of 1,235 miles, the enlargening and deepening of harbors and the connecting channels of the lakes, and the building of powerful rapidly working locks at the Falls of St. Mary, have given such commercial results that any suggestion of improvement upon a wider scale must at once secure favorable notice.

The amount expended by the United States upon lake navigation in widening and deepening channels, is about $12,000,000, and marine history contains no parallel to the rapid development which has been made possible by this assistance. The largest item in the lake traffic, the transportation of iron ore from the Superior shores, has been made possible by the locks at St. Mary's Falls and the deepening of the connecting channels. The importance of this industry, but yet in its infancy, cannot be estimated.

The richest iron ores are now delivered along a line of coast of 1,000 miles, dotted with manufacturing towns. This has cheapened iron and steel below the cost in any other part of the world. The development of this industry has worked a revolution scarcely less important than the enlargement of harbors, channels and locks, in the shipbuilding of the lakes.

As steam took the place of sail, so iron and steel have succeeded wood, and there is no part of the seaboard where vessels can be so cheaply built as in the shipyards of the lakes. These enterprising builders are confined to their own shores. Were they not landlocked in their fresh-water seas, they might compete with the shipbuilders of the world.

The increase of tonnage and freights can be better understood from a table showing the business of the locks at St. Mary's Falls during ten years:

Year.	No. of vessels.	Tonnage.	Net tons freight.
1885	5,380	1,035,937	3,256,628
1886	7,424	4,219,397	4,527,759
1887	9,355	4,897,598	5,494,649
1888	7,803	5,130,659	6,411,473
1889	9,579	7,221,935	7,516,022
1890	10,557	8,454,435	9,041,313
1891	10,191	8,400,685	8,888,759
1892	12,580	10,647,208	11,214,333
1893	12,008	8,949,754	10,796,572
1894	14,491	13,110,366	13,196,860
1895	17,956	16,806,781	15,062,580
1896	18,615	17,249,418	16,239,061

The estimated value of freight in 1895 was $159,575,130.

In 1894 the St. Mary's Falls Canal was open for 234 days, about 10 days more than the average time. The Suez Canal, which is open all the year, passed 3,352 ships, with a tonnage of 8,039,105, or 5,071,261 less net tonnage than the canal connecting the lower lakes with Lake Superior.

The amount of freight passed by this canal in 234 days was equal to 13.6% of all the freight carried by all the railroads of the United States for the entire year.

In 1889 the late Mr. George H. Ely published an estimate of the traffic passing through the Detroit River. He made it three times greater than the foreign trade of the port of New York. It exceeded the aggregate foreign trade of all the seaports of the United States by 10,000,000 tons, and was 3,000 tons more than the foreign and coastwise trade of London and Liverpool combined. At the annual meeting of the Lake Carriers' Association, at Detroit, January, 1896, the statement was made that in 1895 the ton mileage of vessels passing Detroit was estimated at 22,395,251,250. The cost per ton per mile was 0.85 of a mill. The net tons of freight carried was stated to be 20,860,335.

The increase of the business of Buffalo in receiving, storing and forwarding grain and lumber, in shipbuilding, and in general manufacturing is a matter of common knowledge. This may be called the Eastern terminus of deep-water navigation and receives a large proportion of the grain bound to the seaboard. For export and distribution, Duluth, Superior, Chicago, Milwaukee and Toledo all send the greater part of their grain and flour to Buffalo. The table of receipts of grain at Buffalo nearly equals the total exports of grain from all ports of the United States. For three years past the receipts were (reckoning flour in bushels):

1893....	187,235,160
1894....	160,968,095
1895....	162,988,842

At Buffalo bulk has to be broken, the grain elevated and transferred to cars or canal boats, and the same thing, with equal expenses, is repeated at New York.

The lake freight from the farthest shore of Lake Superior and of Lake Michigan to Buffalo is from 1 to 1½ cts. a bushel. The ocean freight averages about 3 cts., making 4 to 4½ cts. for the deep-water carriage of 4,000 miles. The whole cost from Chicago or Duluth to Europe is from 9 to 10 cts. for a bushel of wheat. Therefore more than half the cost is in elevator charges, commissions and canal freights, to which must be added the item of waste.

It costs twice as much to carry a barrel of flour from Duluth to New York as it does from New York to Europe, though the latter distance is more than twice as great as the former.

If an ocean steamer could clear from an upper lake port to Europe, it would save the time and expense required to break bulk at two intermediate points, and the cost of carriage would be about one-half of what it is now. Such a vessel could carry her cargo from the east end of Lake Erie to the ocean for not exceeding 1 ct. a bushel for the additional water distance.

A few years ago agricultural products and lumber made the cargoes of lake shipping, but a new industry has arisen from the recent discoveries of iron ore in the Lake Superior region, which, under favorable conditions of transportation, bids fair to bring about far-reaching, economic changes.

Three-quarters of the iron ore brought into use from these discoveries has been produced during the last ten years, and the amount of capital interested in mining and transportation is now estimated at $234,000,000. The proportion of this recent business to the iron industry of the country may be seen in the statistics of 1892. In that year there was put out 16,036,043 tons of ore, of which the Superior region gave 9,564,388 tons. But when it is taken into account that these ores surpass in richness the ores of any other part of the country, the proportion of value is much greater than appears by weight. New discoveries are constantly reported, and the ease of access to the deposits makes it possible to supply any possible demand. The rapidity of the development of this industry in its infancy seems to establish that, with access to the ocean by a practicable waterway, we can not only control our own iron and steel trade, but can enter into competition in any market. Some of our large iron and steel plants are upon the seacoast and are importers of foreign ores, as the low value of iron ore in proportion to its weight will not permit them to pay railway freights on the ores of the Superior region. The position of these coast iron works is similar to that of the same industry in Great Britain and Germany. The ores of those countries are not suitable for Bessemer steel, and for some years past their furnaces have been supplied from the mines in the north of Spain, which are the only accessible ores in Europe, so far as known, that compare in purity and richness with those of our lake region.

Now the iron masters of Europe are confronted with the discovery that the Spanish deposits are rapidly being exhausted; they will this year supply 6,000,000 tons, four-fifths of which goes to England. At this rate, and with the prices of ore rising as the quantity diminishes, ten years will exhaust the mines of the Biscay region. The other mines of Spain are on the Mediterranean and are small deposits, about 100 miles from the coast.

Another possible resource is in the mines of central and northern Sweden. These are ores of great purity, but low in iron and with a long haul by rail, so that they cannot be cheaply afforded.

This condition of European manufacturing indicates that soon our iron masters can sell their iron and steel in all forms in any part of the world. With deep-water access to the ocean, the ores required on the Atlantic could be supplied to the exclusion of foreign ores, the iron and steel business of the country equalized, and our country supplied at a minimum cost, enlarging the field for capital and industry and increasing the prosperity of the whole. At the same time, furnaces and rolling mills on the lakes could produce iron and steel that, water borne, would irresistibly invade the markets of the world.

Summary of Deductions.

The leading deductions which are to be inferred from the work of the Commission are presented in the following summary:

1. The Trunk Route.

1. All routes are assumed to originate at the head of Lake Michigan at Chicago, and at the head of Lake Superior at Duluth-Superior, thence by Lake Michigan and the Straits of Mackinac and by Lake Superior and the St. Mary's River, respectively, a junction is reached in Lake Huron. All deep-water routes to the eastern seaboard are restricted to two outlets, the St. Lawrence River from Montreal to the Gulf of St Lawrence on the north, and the Hudson River from Troy to the Atlantic Ocean at New York.

2. From the junction in Lake Huron to Montreal and to Troy various routes and combinations of routes have been advocated by diverse interests:

(a) The natural route via Lake Erie, Lake Ontario, and the St. Lawrence River to Montreal, and via Lake Champlain to Troy, with an alternative line from Lake Ontario to Troy via the Oswego-Oneida-Mohawk Valley. An alternative to the Lake Erie route is the direct line via Georgian Bay to Lake Ontario at Toronto.

(b) The Ottawa route via the Ottawa and St. Lawrence Rivers to Montreal and via Lake Champlain to Troy. This line omits Lake Erie and Lake Ontario.

3. The Georgian Bay line is not considered an available alternative for the Lake Erie route:

(a) The work of construction is much more serious, and the same money will develop the Lake Erie route for a capacity which will more than offset the saving in distance.

(b) The water supply is limited for a navigation of the first class, the summit level being drawn upon in both directions, which exacts locks of moderate lifts. The excess of lockage, the number of locks, and the amount of restricted channel increase the commercial length or time on the route, the saving in distance being apparent rather than real.

(c) The ice season is sensibly longer on Lake Simcoe, the proposed summit level, and at Georgian Bay points.

(d) Lake Erie is the greatest traffic lake, and its position will always make it an important factor. The construction of an alternative line would not obviate the necessity of developing the Lake Erie route.

4. The Ottawa route is a short, independent line which may have great value for future development, but its consideration is not now justified:

(a) It is the shortest through route between terminals and is unquestionably adapted to a navigation of considerable capacity. Comprehensive surveys will be required to determine its availability for a navigation of the first class, and until a project has been matured it will be impossible to say how far lockage and restricted channels will offset the apparent saving in distance.

(b) For a large portion of its length it runs through a region meager in resources and the ice season is considerably longer than on the Lake Erie route.

(c) The function of the Ottawa route is as a future loop line for through business when traffic conditions shall have been sufficiently developed by the Lake Erie-Ontario route; provided, it shall be found capable of a radical solution.

5. The routes for shortening distance between Lake Michigan and Lake Huron and between Lake Michigan and Lake Erie are available for a moderate capacity suited to the local and coasting trade. A first-class navigation, if practicable, would be very costly and its utility would be problematical. A large vessel would probably make the longer course through the open water as quickly and the land routes would be closed earlier by ice. They would open earlier in the spring, and this would be a positive advantage, unless means are devised for breaking the ice blockade at Mackinac.

6. A ship route through Western New York along the general course of the Erie Canal is not regarded as a desirable project:

(a) It would involve 120 to 140 miles more of artificial channel than the route via the Niagara Ship Canal, Lake Ontario, and the Oswego-Oneida-Mohawk Valley; it would be crossed by a greater number of bridges and might have as many locks, owing to the conformation of the ground, and it would have a side hill location across lines of drainage for much of its course; all of which would make the route longer for navigation, more expensive to construct, and involve greater risk in maintenance.

(b) All the important points to be reached by such a project, as Rochester, Cayuga Lake and Syracuse, can be better and more cheaply served directly from Lake Ontario or by local canals.

(c) The country to be reached from both shores of Lake Ontario between Hamilton and Ogdensburg is an important consideration. Lake Ontario is comparatively isolated, and to join it with the upper lakes is conceived to be as fruitful in developing commerce as has been the union of Lake Superior, and a project for this purpose would be justified were there no possibilities of going farther in the direction of the seaboard.

(d) A moderate development of the canal through Western New York with a high level through the central lake basin may be of value as a means of water supply for a ship route through the Oswego-Oneida-Mohawk Valley.

7. The question of a trunk route is thus reduced to the natural course through the several Great Lakes. From Lake Ontario the St. Lawrence River leads to tide water at Montreal, and the Lake Champlain and Mohawk routes lead to tide water of the Hudson River at Troy.

II. Terminal Routes.

8. The making of Lake Champlain a part of the Great Lake system is justified independently of any project for reaching the seaboard:

(a) The same considerations apply as in the case of Lake Superior and Lake Ontario, but in higher degree, on account of the very favorable position of Lake Champlain with respect to a distributive traffic through New England and the magnitude of the movement to and from this section.

(b) Except as opening up an increased territory, extension of navigation eastward gives very little advantage over Lake Erie for the trans-shipping and forwarding business until Lake Champlain is reached, which is more favorably situated for a part of the through service.

(c) An extension of lake commerce to Lake Champlain would add 40 to 50% to the length of present lake routes, and a nearly proportional amount of territory in direct service, and would largely increase the total water movement. Lake Champlain is a normal part of the Great Lake system.

9. The St. Lawrence route is justified as a seaboard route on its merits and independent of all other considerations:

(a) Lake navigation at the head of the St. Lawrence rapids below Ogdensburg is 111 miles from ocean navigation at Montreal, with a present length of 46 miles of intermediate canals and 220 ft. difference in level. The artificial channel required for a navigation of the first class is much less than that of either the Suez Canal or the North Sea-Baltic Canal. This route is capable of development to any useful capacity for much less money than any other.

(b) It is the shortest line for direct trade with the north of Europe to the maritime Provinces of Canada. It is recognized that the foreign movement is largely incidental to the lines of domestic commerce, and that by comparison the ratio of domestic movement in this direction is destined to be small; so the St. Lawrence route is not to be taken as a solution of the seaboard problem.

(c) Half of the work required to open the St. Lawrence route is also half of that required to reach Lake Champlain. Considering Lake Champlain as a part of the lake system justifying development, the cost of making the St. Lawrence outlet is very small in proportion to its probable utility. The works to reach Lake Champlain and to reach Montreal should be regarded as parts of one project.

10. The development of the St. Lawrence seaboard outlet and the making of Lake Champlain a part of the lake system in no wise lessen the importance of an outlet to the Atlantic seaboard through the Hudson River:

(a) The predominant seaboard movement on this continent is to and from the Atlantic coast between Portland and Norfolk. This is likely to continue the major factor in domestic commerce and the controlling element in foreign movement.

(b) From Lake Erie northeasterly, the lakes and St. Lawrence extend parallel to the trend of the Atlantic coast and at a distance of 250 to 400 miles. The detour via the Gulf of St. Lawrence to reach this coast is an average trip of 1,830 and 2,000 miles, as against feasible cross routes of 370 and 330 miles. If Lake Ontario were an arm of the sea, the situation would not be materially changed. In other words, for the movement in question, the St. Lawrence route would be of very doubtful utility.

(c) The situation is not unlike and more emphatic than that of France between the Mediterranean and the Atlantic, with physical conditions, such as France does not possess, inviting a water route of the first magnitude. The economic conditions warrant an expenditure several times that required for the St. Lawrence route.

11. With Lake Champlain in the lake system, engineering considerations favor the Champlain-Hudson route from the head of Lake Champlain at Whitehall to tidewater at Troy:

(a) By a cut through the Champlain-Hudson divide the level of Lake Champlain may be carried into the Hudson River Valley and locked down to tide level above Troy in a total distance of 64 miles. The entire route from Lake On-

tario will be downhill and the lockage may be concentrated at three localities in maximum lifts.

(b) The tidal Hudson is favorable to deep water improvement, the amount of material to be moved being no greater than has already been handled in the deepening of the St Lawrence below Montreal, and the mileage of shallow water to be improved is considerably less. In fact, from the common point in Lake St. Francis to the open sea, the mileage of restricted channel by the Champlain-Hudson route is not excessive in comparison with that of the St. Lawrence route. The statements regarding the tidal Hudson are equally applicable to the Oswego-Oneida-Mohawk route.

(c) The Champlain-Hudson route is advantageous to Eastern Canada as a short cut to the southern coasts and to the West Indies. It is the logical extension of a future Ottawa route should conditions favor a radical development on that line, and it skirts New England.

12. Economic considerations favor the Oswego-Oneida-Mohawk route from Lake Ontario at Oswego to tide water of the Hudson River at Troy, provided the physical conditions permit of a radical solution:

(a) The route from Oswego to Troy is 177 miles as against 379.5 miles by the St. Lawrence River and Lake Champlain, or 202.5 miles less in absolute distance. Were the Mohawk Valley in virgin condition it would be feasible to dam it near Amsterdam to the level of Oneida Lake and make a through cut of the Rome summit. Such a treatment would make the route as a whole equal to if not better than the slowest or more restricted 177 miles of channel on the St. Lawrence-Champlain route and save in time the equivalent of the remaining 202.5 miles. This saving on so large a proportion of the commerce as is destined to the Hudson River outlet will be a matter of great moment.

(b) To the extent that vested interests prevent a radical solution will the advantage of distance diminish by increase in the number of locks and through a more restricted channel. An endeavor to mold the works closely to existing conditions may actually destroy the advantage in distance without greatly reducing the cost for a navigation of the first class.

(c) The data show that the route is capable of development for a second-class navigation without radical disturbance of vested interests. The relative value of the route and the capacity to which it may be developed must await final surveys and actual projects, considered on the basis of cost and of economic value. The profile and map, the first ever made of this route as a whole, suggest possibilities not heretofore anticipated, and warrant an exhaustive consideration from final data.

13. Each of the three routes from Lake Ontario seems to have independent merits justifying its construction, and no one of them can be eliminated without sacrificing material advantages. It is easy to believe that the eventual growth of commerce will furnish business for all. Meantime, the determination of the route for initial development should rest on a consideration of all the factors in the problem.

III. Limiting Conditions.

14. The water supply is adequate to a project of any character on all available routes, except the Mohawk, which may require special provision:

(a) The mean outflow of the lakes at Niagara is adequate to a channel three-fourths of a mile wide and 40 ft. deep, with a velocity of 1 mile per hour. Any proportion of this is available for the St. Lawrence and Champlain-Hudson routes.

(b) A through cut of the Rome summit to the level of the lakes of central New York, or a high-level feeder from Lake Erie, will provide a sufficient water supply for the Mohawk route; otherwise, a limited water supply will dwarf the project for a navigation of the first class, as the channel must be fed both ways from a summit, while on the other routes the feed is continuously in one direction.

15. Assuming 30 ft. at standard low water as the limit of depth for a navigation of the largest useful capacity, the proportion of channel to be actually constructed or deepened on any of these routes is relatively small:

(a) In this consideration, it is assumed to be feasible to control the level of Lake Erie so as to produce 16 ft. on the miter sill of the Welland Canal at Port Colborne, or raise standard low water 2.28 ft. by works placed in the Niagara River at Tonawanda and in the Canadian channel opposite, and that the Lake Erie level, less the slope required in the Niagara River, will extend to Tonawanda; and further, that the Niagara Ship Canal is to be constructed from Tonawanda to Lake Ontario at Olcott harbor, via Lockport.

(b) It is assumed that the St. Lawrence River below Montreal has been deepened to 30 ft. The present improvement is for a depth of 27.2 ft., and covers a length of 43 miles of dredged channel. A depth of 30 ft. involves 50 miles of work, and this has already been undertaken.

(c) It is assumed that the Hudson River below the State dam at Troy has been deepened to 30 ft. The project now under way is for 12 ft., and covers 12 miles. A depth of 30 ft. involves 31 miles of improvement.

(d) Between Lake Michigan and Lake Huron, through the Straits of Mackinac, the depth is ample; but a change in the sailing course will be required over a somewhat longer route. Between Lake Superior and Lake Huron, through the St. Mary's River, a depth of 30 ft. involves 27 miles of channel and 1 mile of the St. Mary's Falls Canal.

(e) From Lake Huron to Lake Erie are 43.5 miles of channel of less than 30 ft.; and between Lake Erie and Lake Ontario, 5.5 miles of channel and 25.3 miles of canal.

(f) From Lake Ontario to Montreal and to Troy the constructed and deepened channel will be approximately as follows (the constructed channel may be classified as actual canal and as artificial channel formed by impounding water):

Routes.	Actual canal. Miles.	Channel.—Artificial. Miles.	Deepened. Miles.	Total. Miles.
St. Lawrence River to Montreal..	42.5	20	16	78.5
St. Lawrence-Champlain to Troy.	67	80	52.3	199.3
Oswego-Oneida-Mohawk to Troy.	85	70	12	167

On the St. Lawrence-Champlain route, 20 miles of canal, 20 miles of artificial channel, and 9.8 miles of deepened channel are common to the St. Lawrence route; and 23 miles of canal, 20 miles of artificial channel, and 8 miles of deepened channel are between the St. Lawrence River and Lake Champlain.

The artificial channels are assumed equal in capacity to the deepened channels. How far this may be true and the relative extent of actual canal and of artificial channel depend on the treatment.

(g) From Chicago to Montreal and to Troy the proportion of work is as follows:

Character of work.	St. Lawrence route. Miles.	Champlain route. Miles.	Mohawk route. Miles.
Actual canal	67.8	92.3	110.3
Artificial channel	20	80	70
Deepened channel	65	101.3	61
Total work required.....	152.8	273.6	241.3
Total distance	1,281.5	1,460.5	1,258
Percentage	11.9	18.7	19.1

To the mouth of the Saguenay River and to New York City the proportion of work is as follows:

	St. Lawrence route. Miles.	Champlain route. Miles.	Mohawk route. Miles.
Total work required.....	202.8	304.6	272.3
Total distance	1,558.5	1,614.5	1,412
Percentage	13	18.9	19.3

The distance from Duluth is 67.5 miles greater than from Chicago, and the proportion of work may be computed as above from data under (d).

16. A channel of certain dimensions may be taken as practically equivalent to deep and open water. Without assuming it to have this actual value, a channel one-fourth mile wide and 40 ft. deep is arbitrarily taken as free water for the purpose of comparing the length of free and restricted channels. The distances are taken from Chicago to the mouth of the St. Lawrence at Pointe De Monts and to the Atlantic Ocean at Sandy Hook light vessel. Duluth-Superior will have 67.5 miles more of distance and 48 miles more of restricted channel than Chicago.

Destination.	Restricted channel. Miles.	Total distance. Miles.	Proportion. Per cent.
Montreal	223.8	1,281.5	17.5
Gulf of St. Lawrence.....	333.8	1,698	19.6
Troy—Champlain route	341.3	1,460.5	23.4
Atlantic Ocean—Champlain route	407.3	1,642.5	24.8
Troy—Mohawk route....	300.3	1,258	23.9
Atlantic Ocean—Mohawk route..	366.3	1,440	25.4

In the above tables canal distances are included in restricted channel.

17. The capacity of canals required between Lake Erie and tide water of the Hudson at Troy may be increased 2½ times at an additional cost of 30 to 40%.

18. The deepening of channels in open water, when necessary, will be relatively a minor factor. The deepening of the St. Lawrence below Montreal, and of the St. Mary's River and the passage between Lakes Huron and Erie, furnish sufficient precedent. The material for the most part yields to ordinary dredging operations, and alternate channels offer special facilities at the most serious rock cuts.

19. The question of depth and width of channels between the several lakes and to the seaboard is solely one of cost. Up to channels sufficient for a draft of 27 or 28 feet, every condition seems to lend itself. Beyond this limit the difficulties rapidly increase, and the proportion of restricted channel will be so large as to make the result of doubtful efficiency. Happily, there does not appear to be any economic reason in sight that seems to require provision for a larger draft.

20. The season of navigation is limited by ice, and this varies greatly in different years. The body of the several lakes is capable of winter navigation, and through navigation would be feasible if intermediate channels could be kept open. The ice interruption differs for the several routes:

(We have tabulated the season of closed navigation on the several routes as follows:—Ed.)

	No. days.
St. Lawrence River at Montreal.....	130
Hudson River, at Albany.....	94
St. Lawrence River, Lake St. Francis.....	119
Mohawk Route, Oneida Lake.....	112
Lake St. Clair	100
Straits of Mackinac.....	99
St. Mary's River.....	124 to 145

(h) Ice boats are now in operation that will break 10 ins. of solid ice at 5 miles per hour, and claims are made of ability to handle 18 ins. The great car ferries operate across Lake Michigan and even across the Straits of Mackinac at all seasons and are able to break any field ice encountered and plow through several feet of drift ice. It would seem to require no great development of resources to reduce the ice period to 90 or 100 days from Lake Huron by either the Mohawk or Champlain routes, and if Mackinac proves tractable this period will apply to Lake Michigan. It is possible St. Mary's River would also yield to proper efforts, but no inducement can be held out for the St. Lawrence between Montreal and Quebec as conditions are now understood, unless it be feasible to prevent the actual closing of the river, as has been suggested by a commission of engineers. If commercial necessities should ever so demand, means are likely to be found for still shortening the period, and the experience in high latitudes in the north of Europe is not amiss in this connection.

IV. Capacity.

21. It is assumed that the character of works is to be adequate to vessels of the most economical type, not only for the coasting or domestic trade, but also for the foreign movement, so that commerce may be carried on directly between lake ports and other domestic and foreign ports without transshipment:

(a) Vessels vary in size with the trade in which they are engaged and with the length of route. The ability to obtain cargoes and to deliver them at points capable of distributing or forwarding them promptly, combined with length of route, justifies the largest type of carrier, and these conditions obtain at the great ports only. There are many other ports at which the trade requires a more moderate type of vessel. In this consideration it is assumed that harbors are improved to meet requirements, and this has usually followed closely on actual needs.

(b) The opening up of the lake system to foreign commerce will increase the length of many important trade routes upward of 40%, and will reach directly the producing and consuming interior of the continent, in which, relatively, the largest future growth is to be anticipated. These conditions will make advantageous the largest type of vessel found useful in any trade of the world.

(c) The present type of lake vessel is of flat bottom and broad beam, and is an outgrowth of the demand for large carriers on the small depth of water through the intermediate channels. The limit of economical carrying capacity seems not to have been reached even on the shore lake routes. The type of vessel is not the most economical to construct and operate, and would doubtless be modified in favor of larger draft were there no limit to the depth of channelways.

22. The requirements as now defined demand a limiting draft of 27 or 28 ft.:

(a) Thirty feet is now recognized as the standard depth for first-class harbor entrances. This is intended to provide some margin of depth, depending on the tide, against pounding the bottom in a seaway.

(b) The North Sea & Baltic Canal is built with a depth of 29.52 ft. (9 meters). The North-Sea Amsterdam has a depth of 27.88 ft., and an eventual depth of 35.5 ft. is projected. The Suez was originally constructed for 26.24 ft. (8 meters)), and is undergoing progressive enlargement and deepening. The Panama project adopted 27.88 and 29.52 ft., in different sections, and the Nicaragua project 28 and 30 ft. Corinth and Manchester each has 26 ft. The North Sea Baltic and the North Sea Amsterdam may be taken as the latest type, with depths of 29.52 and 27.88 ft., respectively. To float the same boat in fresh water, these canals would require to be 30.3 and 28.2 ft. in depth, on account of less density.

(c) In 1886 21.7% of the vessels passing through the Suez Canal exceeded a draft of 22 ft. 11 ins. (fresh water, 23.5 ft.), the limiting draft being 24 ft. 7 ins. In 1890, 29.3% exceeded the above, and in 1895, 36.4%. The limiting draft was fixed on April 15, 1890, at 25 ft. 7 ins. (fresh water, 26.3 ft.). The proportion of large vessels between a draft (fresh water) of 23.5 and 26.3 ft. has rapidly increased until in 1895 it was 36.4% of the number and about 44% of the tonnage, as inferred from the usual proportion between draft and tonnage. Half of this tonnage exceeded a fresh-water draft of 24.5 ft.

(d) Freight vessels are in commission with a loaded sea draft of 26 to 28 ft., equivalent to a fresh-water draft of 26.6 to 28.7 ft.

23. Assuming a fresh-water draft of 27 ft. equivalent to a sea draft of 26.3 ft., a good type of boat will have a breadth over all of 60 ft. and a length over all of nine times the breadth, or 540 ft., with a cargo capacity of 11,000 to 15,000 net tons.

(a) Recent lake practice for freight carriers gives a coefficient of displacement of 80%, or the above boat would displace 21,870 net tons. The same practice gives maximum cargo capacity at 68 to 75% of the displacement. If taken at 70%, the above boat would carry a maximum cargo of 15,309 tons. This type may be taken as the extreme limit.

(b) For general service the coefficient may be taken at 70% and the displacement at 19,140 tons. With more machinery and fuel, the cargo ratio may be taken at 60%, and the cargo capacity at 11,480 net tons.

(c) Some of the latest Atlantic liners have coefficients ranging in the vicinity of 60%. Of twenty-three of these vessels built since 1880, eight exceed the above dimensions either in length or beam. This type is not considered of utility for future lake business.

24. The locks required for the above type of boat are assumed to have a depth of 28 ft. on the sills, a breadth of 64 ft., and a net length of 560 ft., with lifts up to 40 ft. where permissible:

(a) The above dimensions give a better leeway than with the boats of the Ogdensburg line, which are built for the locks of the Welland Canal, their extreme width being 3 ft. less than that of the lock, while their length is but 1 ft. less than its net length and their draft is practically the depth on miter sills.

(b) Each of the several canals can be so designed as to bring the locks in the same locality so as to save delay. The single individual lock is considered better than the fleet lock and can be operated more quickly, and the maximum facilities may be provided by duplicate locks.

(c) The lift of locks should be made as great as possible where conditions permit, as time is consumed by the number of locks rather than by the lift. It is believed to be practicable to construct quick-acting locks, with girder gates and lifts of 40 ft., and much of the canal work can be better laid out for large lifts.

(d) With the least possible number of locks, quick operation, and provision for the speedy handling of boats into and out of the lock, much of the objection on account of delays will be obviated.

25. The question of canal prism and channel depth is important, and aside from the question of lockage, the efficiency of works for vessels of the largest class depends thereon:

(a) The subject of ship resistance in restricted channels is a matter requiring comprehensive investigation in view of the proportion of such channels on lake-seaboard routes. In addition to a sufficient ratio of cross section of canal to the midship section of the boat and ample width for two boats to pass, the shape of the section is important. Experience shows that within certain limits and with sufficient width of prism, depth beneath the boat is essential both to speed and carrying capacity.

(b) As a trial section a minimum prism of 10,000 sq. ft. is suggested, or a ratio 5.6 times that of the lock prism and 6.2 times that of the boat, with a depth of about 20% in excess of lock depth and 25% in excess of draft of boat, say a depth of 33½ ft. and a mean width of 300 ft. In some situations greater depth would be justified at the expense of width, and again other situations might make 30 ft. expedient. The general proposition is that when depth is readily obtainable an increase will be advantageous, and this is relatively a small item of cost in the bottom of deep cuttings.

(c) In open water where the depth may be increased at any time, this is a matter of less importance, but depth here will greatly facilitate speed and steering qualities, a matter of importance in channels as crowded as are the intermediate channels of the lakes. On this account and uncertain drifting due to currents and wind, lake interests are asking for widths of 600 ft. and more according to locality for submerged channels, and future conditions will doubtless make expedient a width of one-fourth mile with such depth in excess of draft as may be found readily practicable.

(d) Experience in navigating the Welland Canal shows that the bridges and other structures are a source of vexation, requiring great care in navigation. Every obstruction that checks speed involves loss of steering power and is to be avoided so far as may be possible.

V. Projects.

26. In addition to a project for a navigation of the first class as developed in the preceding sections, a project for navigation of the second class corresponds to present lake development, to much of the coasting trade, and to a vast general commerce with minor ports of moderate harbor depths. It is assumed that such a navigation is satisfied with dimensions in vessels, locks, and canal prisms of three-fourths of those heretofore discussed:

(a) The vessel would have a length over all of 405 ft., a breadth of 45 ft. outside, and a draft of 20¼ ft., with a displacement of 8,000 to 9,200 net tons, and a cargo capacity of 4,800 to 6,400 tons. The lock dimensions would be 420 ft. by 48 ft., with a depth of 21 ft. on sills. The minimum canal section would be 5,625 sq. ft., or a depth of 25 ft. and a mean width of 225 ft. The character of work is set forth in the preceding discussion.

(b) The above dimensions cover the lake fleet, except a few exceptional boats built in the last two years for ore carrying and capable of loading to 20 ft. The largest of these have lengths of 426 to 438 ft., breadths of 45.5 to 48.27 ft., and will carry 6,300 to 6,800 net tons on 19 ft. and 500 tons more on 20 ft. The boats for general service are now well inside the dimensions fixed, but no limit can be given for special trades or even the general service, notwithstanding all routes are inside of 1,000 miles. It is to be assumed, however, that there will always be a trade demanding vessels within the limits set.

(c) It will be seen by consulting the several profiles that the limiting depth at standard low water is, for the St. Mary's River, 17.9 ft.; Lake St. Clair, 18.8; Lime Kiln Crossing, 19.3 ft., and Niagara River, 17 ft. By raising the level of Lake Erie as heretofore described, over 21 ft. would be given from Tonawanda to Lake St. Clair, Lake St. Clair would require another foot and the head of the river at Lake Huron nearly 2 ft. The St. Mary's River will require a deepening of over 3 ft. The depth on the floor of the new lock is sufficient if changes can be made so as to utilize the limit, as in the Canadian lock opposite.

(d) The present limit to Lake Superior is 17.9 ft. and between the other lakes 18.8. By controlling the level of Lake Erie and by continuing the policy of channel deepening at the other points, the standard of 21 ft. may be obtained, and all in line with the policy of ultimate development. The extension of this depth over any route to the seaboard involves no extraordinary works except in the construction of canals. As already set forth, these can be made in essential parts on an ultimate basis without extraordinary increase in cost.

27. As a measure of early utility and pending the execution of new projects, it might be feasible to so amend the Canadian canal system, now nearing completion, as to be adequate to nearly all the lake fleet as developed up to the recent deepening of main channel.

(a) The Lake Superior trade has developed on a depth of 14.2 ft. at standard low water as defined on the lower platform of the lock of 1881, and that of the other lakes on about 14.5 ft. The depths on the sills of the terminal locks of the Welland Canal are 13.7 ft. at Lake Erie and 14.3 ft. at Lake Ontario, and the canal has been open since the spring of 1887. The St. Lawrence canals now constructing between Prescott and Montreal vary from 14.4 to 16.2 ft. on the sills of the several terminal locks.

(b) No sufficient reason appears for the failure to develop a greater trade to Lake Ontario points except the length of the locks, as the upper lake boats had outgrown these before the enlarged canal was opened. The number of locks and the length of time in passage and the lack of an adequate outlet from Lake Ontario may have contributed to the result. The locks are 270 ft. long between hollow quoins and 45 ft. wide, with 14 ft. on the sills.

(c) The boats of the Ogdensburg line are built to conform to the locks, and are 255 ft. in length, or within 1 foot of the possible limit, 42 ft. over all, and carry a cargo of 1,750 net tons, with a depth of 14 ft. on miter sills. With 16 ft. the cargo would be increased to 2,200 tons. If the locks had been 125 ft. longer the cargo would be 3,600 tons, or more than double the present limit, and this is about the limit of the general service boat on the lakes until recently, and represents a very large fleet running in various lines.

(d) To raise the level of Lake Erie as already suggested provides 16 ft. in the summit level of the Welland. Some of the terminal locks require no change and others may be increased, while a few will need alteration or rebuilding. To raise intermediate levels and lock walls and to lengthen the locks to 395 ft. may not be practicable. The ease and cheapness with which this could originally have been done, considering its value, encourages the hope that it may still be feasible to amend the work in progress and completed. A St. Lawrence-Champlain canal could thus furnish an early and valuable service to New England points.

28. The project outlined contemplates a first-class navigation for the largest type of ocean carrier now in use and also a navigation of the second-class adapted to the present interlake trade, to coasting, and to the secondary foreign movement. The several considerations advanced are designed to determine a policy in accordance with which all schemes of work may be projected to some consistent and ultimate end that shall comprehend the greatest possible utility.

29. The control of the level of Lake Erie is desirable if it can be accomplished by works in the vicinity of Tonowanda and on the opposite side of Grand Island, not only as an improvement of the rock channel near the mouth of the Detroit River, but especially as a measure of radical improvement for the Niagara River, and a contribution to the Niagara Ship Canal. It is believed to be justified solely in connection with the passage from Lake Erie to Lake Ontario.

30. No experimental work is involved in the development of any useful depth through the intermediate channels of the upper lakes:

(a) In a route of over 900 miles between Chicago and Buffalo the obstructions to a depth of 30 to 33 ft. are about 44 miles, or about the same as the improved St. Lawrence below Montreal on a depth of 27.2 ft. Of this, 18 miles are through Lake St. Clair, which is understood for the most part to be of the easiest class of dredging and not more difficult than was Lake St. Peters on the St. Lawrence. Ten to 11 miles are near the mouth of the Detroit River and in part is known to be rock. Methods for this work have been developed. If these are too tedious and expensive, it will be feasible to unwater the American channel and execute the work more quickly and satisfactorily and at less probable cost. The remaining 15 miles are scattered shoal stretches which are not known to involve any special difficulties.

(b) The route into Lake Superior through the St. Mary's River involves some 27 miles of deepening aside from the canal. Portions of this are known to be friable and laminated sandstone, which in part yields to dredging, and it is probable that machines would be devised to handle it efficiently if a radical improvement warranting the same were to be undertaken.

31. Eastward from Lake Ontario, the data are in part suggestive only, yet certain features are obvious and no extraordinary conditions are involved except in the magnitude of the works:

(a) The same dredging fleet that has through a series of years deepened the St. Lawrence below Montreal to 27.2 ft. has only to continue in service as it is now doing to produce 30 to 33 ft. The improvement of Lake St. Louis and Lake St. Francis is the continuation of work of a different character, but of much less extent. The improvement of the shallows of Lake Champlain is believed to be less difficult, as the material in large part is probably alluvial. No reason appears why the Hudson River below the State dam at Troy should be more difficult as a whole than that of the St. Lawrence, and the extent of work is much less.

(b) The American shore along the rapids of the St. Lawrence between Ogdensburg and St. Regis seems to be most available for a ship canal of the first class, and it is anticipated that a full survey will develop special adaptation. Between Lake St. Francis and Lake Champlain, the southern route explored by Mr. Barstow seems to have advantages in being some 26 miles shorter than any other and with that much less of shoal water. Detailed surveys will be required to develop its merits. A ship canal from Lake Champlain to tidewater of the Hudson involves a formidable cutting and the damming of the valley above Waterford. Aside from its magnitude there does not appear any obstacles of moment, and the seriousness of these great cuttings, which has grown less formidable in the last few years, may greatly diminish on final study with a view to practical work.

(c) Little further can be mentioned in regard to the Mohawk route. The divide west of Little Falls is a filled-in valley, and this discovery promises a better condition than heretofore assumed. The knowledge brought together in this investigation has developed a more favorable opinion respecting this line, but the best treatment is not yet obvious, and conclusions must await the test of final surveys and a matured project.

VI. Miscellaneous.

32. The ice record is incomplete and general deductions are not warranted. Those records that have been continued for fifty to eighty years fail to disclose any systematic change such as would follow a change of climate.

33. The record of lake fluctuations is also incomplete. These records fail to show any change such as might be due to a change in precipitation and rainfall and the inhabitation of the watershed.

34. No effects on levels have appeared from the progressive deepening of channels except at Montreal, where the water has been lowered locally by a foot or more, and this is obviously due to special conditions in the vicinity. Special study has not been given this matter, however, but it is anticipated that the radical improvement of the passage between Lake Huron and Lake Erie will produce a sensible effect on the level of Lake Huron-Michigan. As most of this effect will occur in the delta of the St. Clair and in the lower reach of the Detroit River, it may be largely masked by the raising of the level of Lake Erie. The improvement of the St. Mary's River may have lowered the water at the locks, and this effect may be anticipated from further enlargement. The radical project herein considered will bring the level at the locks well down toward the level of Lake Huron.

35. The raising of Lake Erie by 2.28 ft. will raise the level of Lake St. Clair by about 1 ft., so far as can be inferred from a study of gage relations, and the effect would disappear at the head of the St. Clair delta. The investigation has, however, not been sufficient for a final determination so as to conclude the matter. No sufficient reason has appeared for the control of the level of the lakes other than Erie, and this is justified in large part in connection with the Niagara Ship Canal.

36. It may be said in regard to future works of navigation that experience in the last few years in this country and Europe have been revolutionary in the development of appliances and in the methods for handling large cuttings, and these can now be undertaken with confidence both as regards cost and time of completion; and, further, that canals in rock cuttings can be so planned as to cost but little more per mile than in the kind of drift so common to canal locations. Further advances in earth removal are to be anticipated in some favorable situations. In underwater work the advance has been notable, and much is yet to be anticipated from the further development of hydraulic dredging. Machines are also in operation capable of handling many kinds of friable and stratified rock. In construction, a desirable advance has been made in the direction of monolithic masonry, which is cheaper and much superior for much of the work in question, and most anything may be attempted in the way of metals. While recent developments have furnished tried resources for every problem, the next series of great works is likely to produce further advances, so that no doubt need exist on the practical side in execution.

The mistakes, if any, are likely to occur from not having considered sufficiently all elements of the problem, and in works of such extraordinary magnitude an error involves a cost in comparison with which any mere cost of proper data and consideration thereof is a vanishing quantity.

The report closes with the conclusions and recommendations which were printed on p. 47 of our issue of Jan. 21.

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The inspection of steam boilers and the licensing of men in charge of them have become common in most of the states, and after people have become accustomed to them scarcely any objections are made to this encroachment by the state upon the liberty of the individual for the sake of increasing the safety of the public at large, which may be endangered by the ignorance or carelessness of such individual. A bill for such inspection and licensing has been introduced in the California legislature, and it is denounced by the San Francisco "Chronicle" as having for its main object political patronage and plunder. Boiler explosions in San Francisco for the last ten years, it says, have been rarer than honest politicians. Concerning the powers of the inspectors it says:

> The opportunities afforded for corruption and chicanery are practically unlimited. An inspector working in the interest of one kind of a boiler might find all others unfit for use, and force the users of steam to purchase the boilers in which he is interested.

Such results have not followed the appointment of boiler inspectors in other states, and we do not believe California will find that any such evils follow their appointment, as the "Chronicle" apprehends.

The reorganization of the scientific service of the United States government, in the interest of more economical and intelligent methods of work, is advocated by Mr. Charles W. Dabney, Jr., Assistant Secretary of the Department of Agriculture, in a late article in "Science." Mr. Dabney points out the duplication of work and the waste of effort, time and money arising from the operation of the present organization, and shows that 28 separate scientific agencies, engaged either in the promotion of pure science or in the discovery and development of the resources of the country, are now scattered through four different departments of the government and three commissions or institutions under government control. The present organization for scientific work is purely of accidental growth, and the majority of the bureaus have no logical connection with the department controlling them. In the earlier stage of our national existence the occasion evidently arose for making some especial investigation or report, and some official, supposed to be particularly well fitted for the work, was placed in charge, without reference to the department to which he belonged. If the line of investigation proved beneficial, or popular, the appropriations were annually increased and an important bureau was in time developed. This accidental connection, once established, has been kept up, despite the recognized incongruities, confusion and waste of effort which it involves. It was in this manner, says Mr. Dabney, that the Coast Survey, Bureau of Navigation and the Marine Hospital and life saving services came to be placed under the Treasury Department, while the Navy Department controls the National Observatory, the Hydrographic Office and the Nautical Almanac.

The disadvantages of the arrangement, under present conditions of development, are apparent. A bureau devoted to pure scientific work is under the head of a department chief, who is too busy with other work to consider its needs, and who is unfitted by previous training to direct in detail even had he the time. The result is that the chief must depend upon a subordinate in charge for the conduct of the scientific bureau; and there is ample room for a conflict of authority between bureaus; duplication of work, confusion in records and a resultant waste of time and money. Mr. Dabney illustrates this by stating that four distinct and separate agencies now measure the land of the country, including here the Engineer Corps of the United States Army; four hydrographic offices exist in as many departments; the magnetism of the earth is being separately studied by the Coast Survey, the Naval Observatory and the Weather Bureau; and five separate government chemical laboratories are to be found in Washington alone. A late board appointed to compile the laws on irrigation consumed one year in finding out how much of this law applied to the Interior Department and how much to the Department of Agriculture. The report of the board showed that to accomplish any intelligent work to benefit irrigation interests, eight distinct bureaus in the two departments had to co-operate. The General Land Office, the Office of Indian Affairs and the Geological Survey, in the Interior Department, and the Weather Bureau and the Divisions of Soil and Vegetable Physiology, in the Department of Agriculture, are all engaged in irrigation investigation; and the last census also reported upon this subject.

These are the conditions under which 5,225 persons are engaged upon scientific and economic works for our government, not including those in the census bureau, and for this work the government annually expends about $8,000,000. It is safe to say that no well managed private corporation would, for a moment, permit such a haphazard and wasteful method of conducting business; and if it did, its stockholders would soon make their complaints heard. The United States is said to be doing more than any other nation in the discovery and development of national resources through these scientific agencies; and the wonder is that so much good has resulted from so bad a system. What is imperatively needed is an intimate co-operation between all these government agencies, and a single competent executive head; whether that head is an individual, or a properly constituted board. As Mr. Dabney remarks, the demand is for a general co-ordination in the scientific work of the government; and Congress should decide upon some definite programme to effect this. An important step has already been taken by placing all the officers and employees of the scientific bureaus in the classified civil service list, as by this action political influence in obtaining employment is practically eliminated, and the use of patronage in securing appropriations or in promoting legislation is almost impossible. Mr. Dabney suggests that a commission of Congressmen, or, better still, of scientific men, should take up this subject, and after a full consideration of the actual needs of the work under modern conditions, present a general plan for reorganizing. It is recognized that many conflicting elements are involved and that revolutionary action would be inadvisable. The change from separate heads to a single executive, in the conduct of scientific work, must necessarily be gradual, and it should come in the course of ordinary business, as each secretary saw an opportunity for transfer of work of this character. But Congress should first adopt a fixed policy in regard to the change proposed, and reorganization will follow.

Mr. Dabney suggests a new Department of Science, and the importance of the work performed would seem to warrant an executive head of high official rank. But the great object of any reorganization scheme is the gathering together of the now widely scattered and practically independent scientific bureaus under one responsible and intelligent control, whether that control is vested in the Secretary of the Department of Science, or in the chief of a new bureau absolutely controlling all scientific work makes little difference. The end aimed at is greater economy in administration and better and more efficient methods in conducting work of this character for the government. All admit that the present wasteful division of effort is the result of accident and accidental conditions, and that reform is needed; but it is also contended that the present development of this work, under distinct heads, combined with bureau policy and politics, will make any change difficult. Both of these contentions only make it more evident that the reform should be commenced, and commenced at once; and the subject is one eminently fitted for speedy Congressional action to pave the way towards the much needed reorganization.

The Nebraska "State Board of Civil Engineers" will be a decided novelty, if the bill of Senator Beal, now pending in the legislature of that state, is passed. According to the bill, this board is to be made up of the Governor, the Secretary of State and the Attorney General, who may appoint three secretaries. These secretaries are to do the work of examining engineers and surveyors wishing to practice in the state, and a certificate from this board, costing $5.00, will be a necessary preliminary to such practice thereafter. The secretaries are to receive no compensation other than the fee mentioned and the regular notarial fees for taking testimony. To any one outside of Nebraska the presence of the Governor and his staff upon this board seems superfluous; and it would also appear that the three secretaries, if engineers at all, can certainly not be accused of holding their professional services at an extravagant figure. The payment of a $5.00 fee by engineers and surveyors to three friends of the Governor is evidently the chief purpose of this absurd bill.

A little stir of interest over the meter question in Brooklyn, briefly noted elsewhere in this issue, brings to mind a statement previously made in these columns. The general idea advanced was that when consulted regarding deficient water supplies engineers seldom advise the curtailment of waste, but concentrate their energies upon providing additional water. There are a number of reasons for this, which we cannot discuss now, some of which, under certain conditions, are very good ones.

Brooklyn is said to use about 80 gallons per capita per day. This is not a large amount compared with some cities, but taking into account all the local conditions, undoubtedly includes much waste. This waste would be greatly reduced if those responsible for it were paying for water on the basis of consumption and use, instead of arbitrary fixture rates.

Certainly if any city should conserve its water supply it is Brooklyn, for as soon as its resources on Long Island are exhausted, it cannot get more water except at great expense, owing to the distance which it must go for water and the natural difficulties to be encountered in bringing water to the Island.

In our illustrated description of a concrete pier for the Cascade Bridge at Burlington, Ia., in our issue of Dec. 17, we stated that the plans for the bridge were made in the City Engineer's office under direction of Mr. Emmet Steece, Assistant City Engineer. We should have limited this statement to the substructure only, to which the article had special reference. The plans for the superstructure were made in the office of Boynton & Warriner, of Cedar Rapids, Ia., and the erection was superintended by the junior member of that firm.

THE DEEP WATERWAYS COMMISSION'S REPORT.

We give up a considerable space in this issue to a reprint of the most interesting portions of the report of the "Deep Waterways Commission," which was appointed a year ago "to investigate and report whether it is feasible to build such canals as shall enable vessels engaged in ocean commerce to pass to and fro between the Great Lakes and the Atlantic Ocean." Briefly summarized, the report of the Commission is to the effect that it is feasible to construct such channels

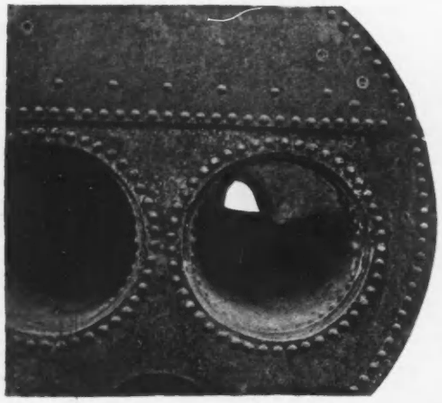


Fig. 27. Buckling Downward of Flue Plate.

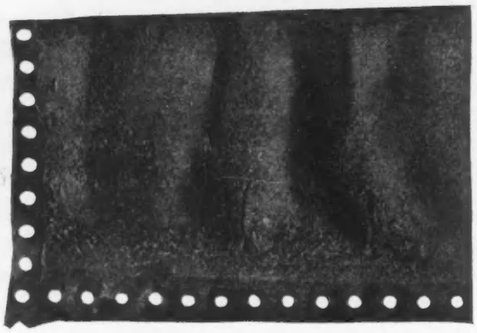


Fig. 28. Plates Cracked by Wave-Shaped Bulges.

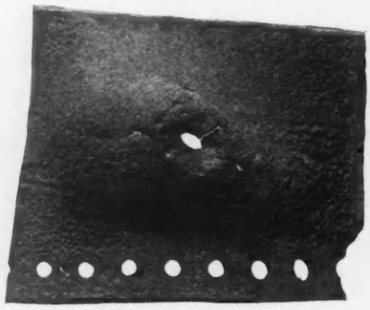


Fig. 31. Ruptures in a Bag or Pocket Bulge.

Fig. 25. Bag or Pocket Bulge.

Fig. 26. Inward Buckling at Circumferential Joint.

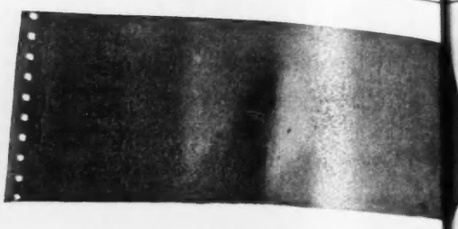


Fig. 24. Wave-Shaped Bulges in Fire Plates.

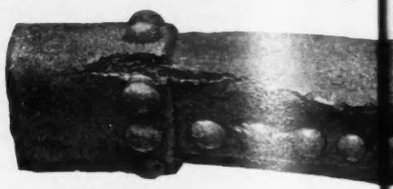


Fig. 30. Longitudinal Crack in a Buckled Flue.

Fig. 29. Rupture at Bulge in a Laminated Plate.

GROUP I. DEFORMATIONS. (FIGS. 24 TO 31.)

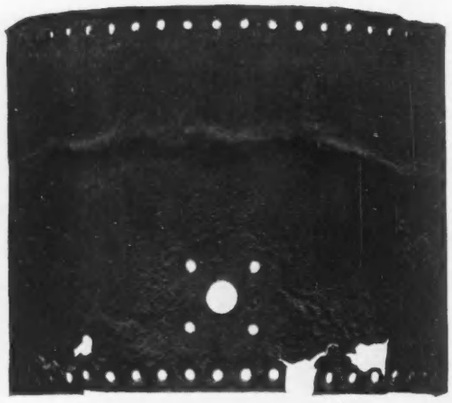


Fig. 36. Examples of Local Rusting.

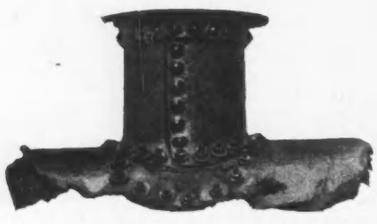


Fig. 39. A Bad Repair Job—Patch Bolted on Inside of Shell.

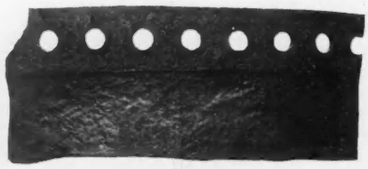


Fig. 32. Corrosion Caused by Leakage Through Seam.

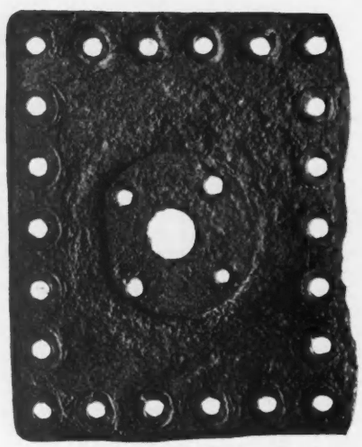


Fig. 38. Corrosion from Leakage around Flange of Steam Pipe Joint.

Fig. 40. Corrosions on Vertical Flues.

Fig. 33. Corrosion from Leakage Through Cracks between Rivet Holes.

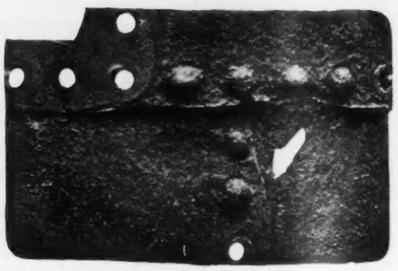


Fig. 37. Example of Rusting at Junction of Joints.

GROUP II. DEFECTS CAUSED BY EXTERNAL CORROSION. (FIGS. 32 TO 40.)

TYPICAL DEFECTS

Collected by a Committee of the Aus

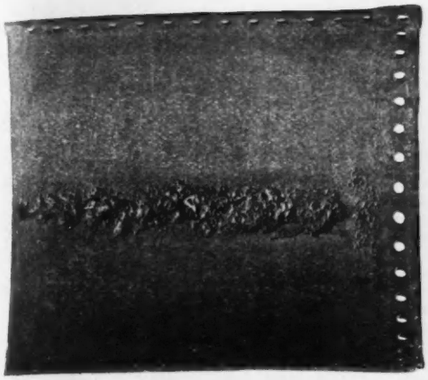


Fig. 44. Internal Corrosion Due to Burning the Plate Above the Water Line.

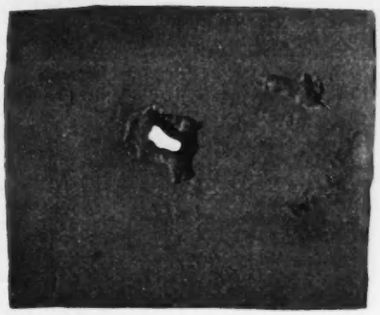


Fig. 41. Deep Pits through a Plate.

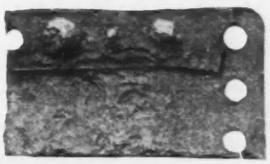


Fig. 46. Corrosion of Interior Rivet Heads.

Fig. 42. Deep Pits with General Corrosion.

Fig. 47. Pitting on Water Side of a Tube.

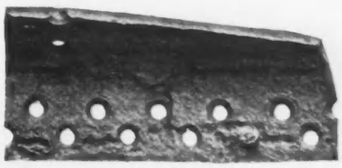


Fig. 45. Grooving at Bend of Sheet.

Fig. 43. A Case of General Pitting.

GROUP III. DEFECTS CAUSED BY INTERNAL CORROSION. (FIGS. 41 TO 47.

Fig. 35. General Corrosion of a Plate.

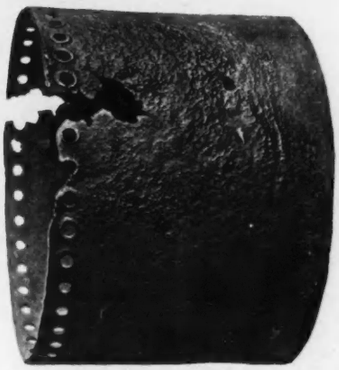


Fig. 34. Corrosion Extending Through Shell.

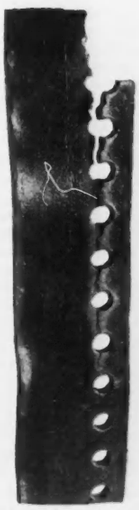


Fig. 51. Crack Through a Seam.

Fig. 50. Cracks Through Rivet Holes and Groove Made by Calker's Chisel.

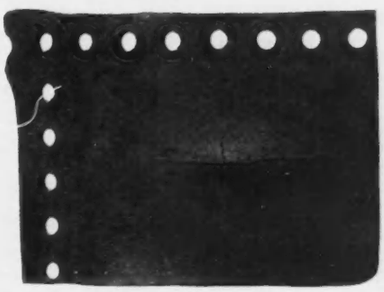


Fig. 52. Through Cracks at an Incipient Bulge.

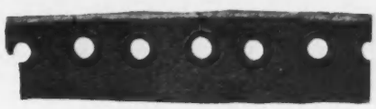


Fig. 48. Short Cracks at Rivet Holes.

Fig. 49. Cracks Through Rivet Holes and at Edge of Plate.

GROUP IV. CRACKS AND RUPTURES (FIGS. 48 TO 52.

to accommodate vessels of any desired class, but in the opinion of the Commission the navigable depth of such channels should not be less than 28 ft.

We consider it extremely unfortunate that the Commission construed its instructions so literally. It has confined itself almost entirely to the discussion of the feasibility of making various channels of various capacity over various routes, and has left practically untouched what we have steadily maintained to be the fundamental question in connection with this enterprise, and the one which should be settled first of all, viz.: Is a ship canal the best solution of the problem of freight transportation from the Great Lakes to tidewater?

With some few exceptions, which we shall presently note, the Commission has nothing to say on this question. It takes it for granted that a ship canal would greatly reduce the cost of transportation between the Lake ports and tidewater, as well as between the Lake ports and European markets; and not only this, but it gives no hint anywhere that the cost of ship canals might be so great as to make the enterprise a losing one. The Commission lays such stress on the volume of traffic over this route and its probable future growth that it is apparently well convinced that the ship canal will pay, no matter how great may be its cost.

Perhaps this is all true; but why should it be taken for granted? To many students of the problem at least, it is by no means a self-evident proposition that a ship canal over the proposed route would mean the cheapest possible transportation. Or if it would mean it to-day, what certainty is there that it would mean it twenty years or forty years hence?

We are strongly inclined to believe that Congress and the President in creating this Commission intended it to consider the very things it has not considered. What the Commission has done is to discuss the relative merits of different routes for a ship canal and the feasibility of canals of different depths and capacities over various routes. But these are engineering questions pure and simple. Had it been the intention to make these the chief questions of consideration the commission should have been made up entirely of engineers. As it is, with all due respect to President Angell and to Mr. Russell, the report is evidently the work of Mr. Cooley, and is so of necessity, since for the most part the questions discussed are purely engineering questions, on which he alone of the three members of the Commission was competent to render an opinion of value.

But it may be said, too, that for the most part the questions which we maintain are fundamental and should precede the study of routes are also engineering questions and can only be intelligently studied and solved by engineers. We cannot attempt within the limits of our time and space to discuss them exhaustively here. All we can attempt to do is to point out some of the directions in which the Commission should have extended its investigation in order to carry out the spirit if not the letter of its instructions.

In the first place we find that the Commission dismisses the important subject of railway competition in a single line, as follows: "The limit of reduction in railroad freights seems to have been reached." This is a pretty broad statement to put forth without support by a single word of evidence; and we are curious to know on what the Commission bases its conclusions. It is perfectly well known that the course of freight rates and the cost of freight carriage per ton per mile by rail has been steadily downward ever since the origin of the railways, and up to the present time this reduction still continues. Why, then, should it be thought that an end to improvements in railway freight transportation has been reached?

As the Commission does not answer this question, we will try and answer it for them. Turning to Poor's Manual we find that the average freight receipts per ton mile on the railways of the Middle States, which were 1.04 cts. in 1883, went steadily downward year by year until they were 0.71 cts. in 1893. It is evident that if this rate of decrease were to be maintained, in a little more than a quarter century the railways would be carrying freight for nothing. Manifestly a stop must be made short of this point. Again one reason for the fall in freight rates has been that under the pressure of circumstances the railways have reduced their charges for freight faster than they have reduced their operating expense account. In other words, the railway stockholder has turned over to the shipper a good proportion of the earnings which formerly went to pay dividends. But this has gone so far now that the stockholder has precious little left to divide—or the bondholder, either, for that matter. Future reductions in the charges for freight transportation must result from actual economies in the cost of carriage.

Now there is unquestionably some reason to believe that on ordinary railways the cost of freight transportation has been reduced to very nearly its lowest terms. The New York Central, for example, has carried wheat from Buffalo to New York at a rate as low as 3 cts. per bushel, or equivalent to 0.2 ct. per ton-mile. While the road did not lose money even at this rate, it certainly is very close to the lowest that will be permanently possible on ordinary railways for bulk freight.

But on the other hand, there is good reason to believe that the cost of rail freights may be still further reduced on lines where an enormous volume of traffic is to be handled by building railways solely for freight traffic and utilizing to the fullest degree all modern methods for cheapening the cost of rail transportation.

There has been a great deal of talk at one time or other respecting a ship canal from Pittsburg to Lake Erie for the carriage of iron ore, coal and coke. Mr. Andrew Carnegie decided not to wait for a ship canal, and he is building instead a railway which is to be an innovation in railway construction. It is being built especially to move freight traffic at the smallest cost. The grades and curves are the easiest that the topography permits; the track is laid with 100-lb. rails. The cars will all be built of steel and will be of 100,000 lbs. capacity. The locomotives will be machines of enormous weight and power, able to haul enormous trainloads at high speed. As neither passenger trains nor way freights will be in the way, the trains can run through from terminal to terminal without delays for switching, and automatic loading systems will make short delays to cars at either end. We advise the Deep Waterways Commission to examine this latest enterprise of Mr. Carnegie, and then see if they do not wish to revise their statement that "The limit of reduction in railway freights seems to have been reached."

Leaving this subject for the present, let us turn to another point in which the Commission appears to us to take too much for granted. It assumes all along that a very deep channel (28 ft.) will be the most economical and in fact recommends this. But it appears to us that this is emphatically a question which only a careful study and comparative estimates can settle. For example, it is stated in the report that the present Lake fleet has been developed on an available depth of only about 14½ ft. In other words a channel with 16 ft. depth of water would accommodate nearly all the present Lake fleet. These vessels have reduced the cost of carrying grain from Duluth to Buffalo, 1,000 miles, to from 1 to 1½ cts. per bushel. The cost of the ocean freight from New York to Liverpool (3,000 miles) averages about 3 cts. Both these figures are given by the Commission itself. By its own showing, then, the Lake steamers, notwithstanding their winter idleness, their shorter voyage and their trips light, on account of the bulk of the traffic being in one direction, have reduced the rate per ton mile to a point nearly as low as that of ocean freights.

The Commission does, indeed, propose what it calls "a project for navigation of the second class," but it contemplates a depth of 25 ft., which would make it well nigh as expensive as the "first class project," which is what it chiefly recommends.

Of course the ground on which the Commission bases its recommendation for very deep water is the well-known fact that ocean steamers of the largest size appear to be the cheapest freight carriers, and it assumes that given a ship canal of sufficient depth, the freight steamers of the world will go up it and load at the Lake ports.

But is this after all a self-evident fact? Suppose a 28-ft. channel were completed to the Lakes? Would the owners of a million-dollar vessel send her up a thousand miles of inland waterways, through chains of locks with a total ascent of over 600 ft. to get a cargo at Chicago or Duluth? Perhaps they might if it paid to do so; but on the other hand, with such a waterway could not the present Lake steamers, which have so phenomenally lowered the cost of freight on the Lakes, continue on down to the harbor of Montreal or New York and transfer their load to the ocean vessel more economically than the ocean vessel could go to the Lake port herself to load? If that should prove to be the case, the cost of obtaining 30 to 33 ft. depth of water would be a pure waste, for 16 ft. would accomplish practically the same end.

The fact is there is a deep-seated fallacy in the assumption that by any device imaginable the Great Lakes can be made into an arm of the sea. What the Commission is pleased to call "restricted navigation" is not the equivalent of the open ocean and cannot be made the equivalent. An ocean going vessel must move more slowly in such a channel and must encounter more risks, including the risk that a break in a minor part of any one of a chain of 30 or more locks may shut the vessel up in the Lakes for an indefinite time. Further, it requires a more expensive vessel and equipment for the North Atlantic trade than suffices for the Lakes, and the interest and wages account while such a vessel was crawling through 300 to 400 miles of "restricted channel," might easily make her a more expensive carrier than a Lake steamer or barge.

Of course an answer to this can be given to the effect that any break in the shipment involves the cost of transfer of freight; but this should not be made a bugbear. It is not something to be avoided at any cost, but a thing to be carefully estimated, and eliminated if it can be eliminated at a profit, but not otherwise.

It appears to us that the Commission is somewhat unfair in discussing this aspect of the problem. It says that more than half the cost of carrying a bushel of wheat from Duluth or Chicago to Europe is "in elevator charges, commissions and canal freights." Suppose this is true at the present time? Is it necessarily a permanent situation? Suppose elevator charges at Buffalo and New York are three or four times the actual cost of handling the grain? Should they be figured at this artificially high rate in estimating the advantages to be derived from a ship canal?

We have said that the commission has left practically untouched problems which it ought to have handled. The problem which it has undertaken to solve, however—that of the best route for a deep waterway from the Lakes to the Atlantic—has certainly received a more systematic treatment than ever before been given to it.

The Commission's conclusion is that the St. Lawrence River is the best route by far for such a waterway, and it evidently is more favorably impressed with the Lake Champlain route as a means of reaching the Hudson than with the Lake Oneida route, with its long chain of locks. As for the project for a ship canal from Lake Erie to the Hudson direct, the Commission holds it quite out of the question compared with the other routes named. The Ottawa route, which has been so much talked of, it also discards, partly for the reason that so little is known concerning it that not very much definite can be said, and partly because it is a through route only and could have little local traffic.

We have criticised the Commission for what it has not done; but the work that it has done is certainly of a high order of merit. Mr. Cooley, who has borne the laboring oar, has accomplished wonders with a very small amount of money, and he deserves the greater credit because his work is entirely a labor of love. Congress, with that cheese-paring economy which too often distinguishes it expressly provided that no member of the Commission should receive any compensation for his services. The comparison of the merits of the various routes which has been made is certainly an interesting one, and since the topic has so long been a subject of discussion among engineers, we are sure our readers will follow it with interest. The abstract which we publish on another page is, of course, only a small part of the report, and we strongly urge our readers who are interested, and especially those in charge of the libraries of engineering societies to secure a complete copy of the report. They can probably secure one by addressing the Superintendent of Public Documents, Washington, D. C., and requesting a copy of "Document No. 192, 54th Congress; 2d Session."

In conclusion we desire to again lay especial emphasis on the fact that the work which this

Commission was appointed to do, but has not done, ought to be done and carefully done before further steps are taken in this enterprise. As the "Journal of Commerce" well says:

The conclusions of the Commission enunciate several undisputed things, but do not shed any light on the really important points at issue. They counsel the undertaking of works involving a huge expenditure without venturing to calculate either the amount required or the probable return to be derived from it, and without assigning any sufficient reason why the works should be undertaken.

The question is not as to the possibility of certain comparatively simple engineering achievements, but as to their necessity and the likelihood of their proving remunerative.

The problem that should be solved is: What is the cheapest method of freight transportation from the Lake ports to the seaboard and to foreign ports? To assume without proof that a ship canal is necessarily the answer to this question is wholly unjustifiable.

The enlarged Erie Canal, with mechanical towage, and with companies operating the boats equipped to do business according to modern methods, transferring freight at terminals by the best machinery and paying no extortionate charges to elevator owners can doubtless handle freight at much less cost than at present.

The operation of through barges on lake and canal, as developed by the Cleveland Steel Canalboat Co., is another promising direction for reducing the cost of carriage, giving a through transit without breaking bulk from the Lake ports to tidewater. In a similar line are the new Canadian canals, by which it will soon be possible for a vessel drawing 14 ft. of water to go from Duluth to Montreal.

The possibilities of the future in very cheap movement of bulk freights over rail lines built especially for such traffic also deserve to be investigated. To merely sketch out such a scheme, it would be a comparatively inexpensive work to improve the Hudson so that all classes of ocean freight steamers could ascend to a point 12 miles below Albany. Suppose docks and transfer wharfs were erected at this point, and a special freight railway were built to Buffalo, 300 miles, located solely with regard to handling the heaviest possible trains at the minimum cost between the terminal points? Grades would be made exceedingly light and for the most part would be in the direction of the traffic. The terminals would be so arranged that cars would be loaded from the steamer's hold at one end and would discharge directly into it at the other. The traffic arrangements would be made entirely without complication from passenger or local freight traffic. The rolling stock would be of the heaviest class. Cars of 100,000 lbs. or even greater capacity would be made up in solid trains carrying 50,000 to 100,000 bushels of grain, and run through to destination at speeds which would make the cost of trainmen's wages a small item. Looking far into the future it is even possible that the transmission and utilization of electricity may some day be developed so that the power of Niagara and of the rivers of central New York would be utilized to haul these enormous loads at less cost than the steam locomotive.

We cannot pretend to say that a railway on such a plan could compete with a barge canal or with a ship canal via Lake Champlain and Montreal, if one were built; but to any one who has studied recent progress in the cheapening of railway freight transportation it certainly is an interesting proposition.

We contend that all these plans—railway, Erie Canal, Canadian canals, 16-ft. canals and 28-ft. canal ought to be carefully weighed on their merits. If the ship canal is all its advocates believe, it probably ought to be built; but they ought at least to be able to give reasons for the faith that is in them.

LETTERS TO THE EDITOR.

Honesty Among Engineers.

Sir: The publication in your issue of Jan. 28 of the sharp and merited rebuke administered by a chief engineer to the President of a Construction Co. will have undoubtedly a salutary effect in discouraging dishonorable approaches to professional men in positions of trust and confidence.

In the postal card terminating the correspondence which you publish, there is, I think, a misstatement of fact. I believe that if it were possible to gather the statistics of the case it would be found that those engineers who are accessible to such approaches are in the small minority. We hear but little of the many cases where attempts at corruption are quietly but firmly set aside; it appears that some more public repulse, such as that which occasions this letter, is needed for the benefit of those who are laboring under a misconception of facts. There are more honest men in the world than the rogues give credit for.

Yonkers, N. Y., Feb. 3, 1897. E. S. G.

The "Black Printing Process."

Sir: I note on p. 43 of Engineering News, an article on Black-Printing. I have had no experience; but the following formula is from the 1897 "Photographic Times Almanac," and it is officially given as the standard up-to-date process; I have no doubt it is the best published:

Water	9 ounces.
Gelatine	3 drachms.
Perchloride of iron solution (U. S. P.)	6 "
Tartaric acid	3 "
Ferric sulphate	3 "

Filter off any precipitate that may be found and coat any good stout white paper (e. g., Steinbach medium roll) with the full strength solution. Expose in sunlight till details or lines are visible, and develop with—

Gallic acid	6 drachms.
Alcohol	6½ ounces.
Water	32 "

Wash the sheet well in several changes of water.

Gallic acid is a different thing from tannic acid or tannin; it may be had from any of the large dealers in chemicals; ferric sulphate is also known as persulphate of iron, and is not the same as ferrous sulphate, or copperas. A. H. Sabin.

Long Island City, N. Y., Jan. 23, 1897.

The Riachuelo River Sewage Siphon at Buenos Ayres.

Sir: In connection with the sub-aqueous aqueduct in New South Wales, described in Engineering News of Jan. 21, 1897, a brief description of a siphon recently built on the line of the new outfall sewer for Buenos Ayres may be of interest.*

The siphon takes the sewage of the greater part of the city, whose population is something over 680,000, together with ¼-in. rainfall per day, under the Riachuelo River. From the fact that no stone is found in the vicinity and that the bed of the stream consists of soft clay and fine sand to a considerable depth (over 90 ft. at the site of a neighboring railway bridge), the conditions were peculiar. The difficulty of the work was increased from the fact that the stream is subject to very destructive floods from the heavy rains which occasionally occur. As an instance, it may be said that on Sept. 22, 1884, 9 ins. of rain fell in 24 hours, raising the stream 11 ft. above normal high water. For this reason the use of cofferdams was not attempted, but the siphon was constructed of four self-supporting spans, 52 ft. in length, resting on piers and abutments. Each abutment consisted of two brick cylinders resting on curbs, 11 ft. in external diameter and 32 ft. c. to c., and containing horizontal plates tied together by vertical bolts at intervals. These cylinders were sunk 33 ft. below the river bottom and had a total height of 58 ft. The excavation in these was done by hand and after this and the sinking was complete three of the four were filled with concrete, a chamber being left in the fourth for draining the siphon by a pulsometer pump.

A circular cofferdam of 14 × 14-in. square sheet piles was built connecting each pair of cylinders with a diameter of 32 ft., the diameter extending from center to center of piers, and in this was provided a proper foundation for the siphon chambers, valves and superstructure. Near the upper abutment a sludge pit was provided, and the lower one contained the pulsometer pump and boiler for draining the siphon for cleansing or repairs and a fan blower for ventilating the same. Each abutment also contained six cast-iron pipes, 30 ins. in diameter, with valves, which connected with the horizontal siphon.

There were three intermediate supports or piers, consisting of cylinders of brickwork, 12½ ft. in diameter, resting on wrought-iron curbs and sunk, from stagings, to a depth of 25 ft. below the level of the under side of the siphon. To overcome the skin friction the piers were loaded with about 300 tons each while being sunk. They were then filled with concrete, giving a bearing surface of 120 sq. ft. and a weight per sq. ft. of 3½ tons.

The horizontal portion of the siphon was built of three elliptical cast-iron tubes, surrounded by not less than 18 ins. of concrete, in which, between the tubes, were imbedded two wrought-iron lattice girders, and the whole inclosed in an elliptical casing of wrought iron.

The structure was built in four spans of 52 ft. each. The wrought-iron casing, stiffened by bulb-iron rings, was built on the shore with temporary tie rods in the direction of its major (horizontal) axis to withstand the hydrostatic pressure when submerged.

The three elliptical conduits, 5 × 2¼ ft., with the two 52-ft. girders, were then put in place, and the casing with its contents lifted by a floating derrick, taken to its proposed location and, filled with water, lowered to its permanent position, 2 ft. below the river bed, with the ends resting on the piers, a channel having been dredged in the river bottom for its reception.

The ends being inclosed by temporary bulkheads access to the interior was had by temporary shafts, 5 ft. in diameter, at each end reaching to above high water, and the spaces between the casing and the three tubes were completely filled with 5 to 1 concrete. Before this was done the span was loaded so as to produce its final deflection, and as the concrete was put in place this load was removed. The joints between the spans were formed of concrete, the bulkheads at their ends removed and the adjoining spans connected by special castings.

The work was designed by Mr. J. F. La Trobe Bateman.

Very truly yours,

Baltimore, Md., Jan. 26, 1897. Kenneth Allen.

*From data given in a description of the sanitary work of Buenos Ayres by Hon. R. C. Parsons in Proc. Inst. C. E., vol. cxxiv., 1896.

The Question of a New Nicaragua Canal Survey vs. Engineering Ethics and Facts.

Sir: It is with some feelings of surprise that I notice what seems to me the narrowness of your editorial in the issue of the News of Jan. 28, and partisan views of an extreme character. This appeals to one only as an undignified abuse of editorial power inflicted on unwilling readers, unless justified by facts that are not at once apparent in your article. For this reason I trust you will admit that the following has some justification, as a desire for better light on the subject of the proposed canal survey. To many of the engineers employed on the Nicaragua Canal survey, much that is implied, in your articles and in the report of the Commission, is both unjust and incorrect and the standpoint untenable. No good reasons have at any time been given, no definite plans have been formulated, no ultimate aim seems fixed about this proposed survey. This is the opinion of engineers whose acquaintance with this problem was gained through years of hard work, self-denial, and hardships; and now we are asked to yield all to the views of a Commission whose actual time spent in a hasty examination of the Canal line numbered days in contrast with our years, or scarce that many hours of study by the writer of the editorial in question. Thus far every suggested scheme advanced has been fully answered, or can be from data easily available without a trip to Nicaragua, and any new scheme with a definite basis of any merit would be refreshing. Certainly until this happens and is worthy, the matter of a new survey is aimless and uncalled for. As an engineering authority ever ready to defend the Commission as engineers, and properly if correct, you are attacking the integrity of the work of engineers whose merit is no more assailable, while their experience in this particular problem is immeasurably greater; surely this should be explainable or it is most unjust. An undeniable fact is that this trip to Nicaragua and the spending of an ample appropriation was productive of no new data or ideas; the actual time on the line of the Canal being less than two weeks with no instrumental work of consequence, the report you mention being merely an incomplete review of the Canal Company's data. This is not very meritorious, or encouraging enough to send other expeditions, unless there is some definite work to be done that is as yet undone. To the careful student, the limitations of the problem of Canal location are economically most narrow, and to spend money and energy in a desultory manner beyond the limits of such discrimination is not engineering or business. In all work the projector clearly decides in advance by a careful examination of all existing data and an inexpensive reconnaissance, perhaps, whether there is any necessity for detailed work and just what it is; here we are asked to believe there is a necessity for a $350,000 survey, but to do what, and to what end that has not been already accomplished? Surely this is worthy of as much energy in explanation as evinced in your article, and perhaps some one who gained knowledge of Nicaragua and its swamps and fever can give a good reason why it should not be so, rather than from the critic on unassimilated or incomplete information. The only criticism thus far that may seem justifiable, of the former surveys, is the meagerness of certain stream flow and borings data. This, as stated in another article, can only be remedied in a certain degree, and be of doubtful further advantage, depending solely on the judgment of application for its value or harm. Surely this is a somewhat baseless foundation on which to advocate an expensive and lengthy survey. It looks as though all that would be accomplished would be either a rethreshing of old data or a collection of new, not pertinent to the problem and which a careful judgment could discriminate against beforehand, and to do this, there is more complete and valuable data in the surveys of the Nicaragua Canal Construction Co. and former surveys of the U. S. Government than any enterprise has yet been blessed with or will be for many a day. My plea is to use them properly and completely, or let some one who understands do so for you, not incompletely, or as a partisan, except for good toward worldly progress, as is the duty of the engineer.

Yours truly,

Boyd Ehle, C. E.

Late Chief Draftsman and Chief of Party, Nicaragua Canal Co., for four years in Nicaragua.

Tonawanda, N. Y., Jan. 29, 1897.

(Our correspondent appears to have wholly misunderstood the purport of the editorial note in

our issue of Jan. 28, as well as the attitude of this journal toward the Nicaragua Canal. As we said at that time, this journal is and always has been one of the strongest supporters of the Nicaragua Canal enterprise, and it firmly believes that the most serious injury that has ever been dealt to that enterprise is the unwise attempt to force a government guarantee of the company's securities in the face of the report of the engineering commission.

Our correspondent apparently thinks that the public ought to take the statements made by the canal company's engineers and those made by the Government's own engineers on an equal basis, or rather that much greater weight ought to be given to the former because of the vastly greater time which they spent on the work. But the public will do nothing of the sort, and would be very foolish if it did. Suppose a banking firm is asked to invest in the bonds of a railway company and the reports of the company's engineers are submitted to it. Does the firm rely on those reports or on the reports of its own expert engineers, which it sends out to examine the property and report as to the security of the investment?

The case is simply this: A company asked the United States Government to invest $100,000,000 in its enterprise. The United States very wisely said: "We will send our own experts there and verify the reports of your engineers before we invest." Very unwisely, however, Congress limited these experts both in time and expenditure, so that they were unable to make anything like a complete investigation of the enterprise. They were obliged to come back and report this and to say that from such investigation as they were able to make they were of the opinion that the cost of the enterprise would be largely in excess of the company's estimates, and that the Government ought to make fuller surveys and settle a number of disputed points before it invested in the enterprise.

Now suppose for the sake of argument that the Commission was over-conservative, prejudiced if you will, or even derelict in its duties. Cannot our correspondent understand that even if that were the case it is entirely impolitic for the canal company to try and discredit this report? The railway promoter comes into the banker's office and says: "My dear sir, I know your engineers have reported that it will be well for you to investigate farther before buying the bonds of my road; but really it is all needless; my own engineers have done everything necessary; you may rely implicitly on them." Is the banker strongly impressed by the advice?

The fact is,—and it is strange the Nicaragua Canal promoters cannot see it, the report of the engineering commission cannot be set aside or ignored. The attempt to do so has actually made the general public think that the report was adverse to the enterprise itself, whereas this was by no means the case. The public will not believe the Nicaragua Canal Company's engineers in preference to the Government Commission, and as a matter of fact we know that some at least of the company's former staff strongly favor the fuller investigation which the commission advised.

Our correspondent accuses us of partisanship and of taking an unfair advantage of our editorial position. We believe if he carefully reviews all we have said on this topic he will take a fairer view. We published very fully the report of the Commission and also the report of Mr. Menocal in reply thereto, so that our readers could study both sides of the matter and form their own conclusions. We have published letters from many engineers of the canal company besides himself, both attacking and defending the company's position. Our editorial columns are for the expression of editorial opinions, and any one who chooses is at entire liberty to differ from them. The course of events seems to prove that we were right, however, in urging that the additional surveys recommended by the Commission should be at once carried out. The attempt to ignore this and to push through the original guarantee bill has resulted in a delay of over a year, has made a host of enemies for the enterprise and seems doomed to a final failure after all.—Ed.)

Engineering News as a "Watch Dog of the Treasury."

Sir: A closing paragraph in an editorial in your issue of Jan. 21 is as follows: "But how Congress is to be induced to give up its present privilege of playing engineer as well as appropriator of money, is a question we will not attempt to solve." This serves me as a text to impose on you my views, which I am not writing for publication, but that you may see how some people think on this subject. My response is that you should attempt to solve this, and all other similar questions.

It is a marked feature of our legislation, municipal, state and national, that those who want anything are always ready to ask for it, while those who are not closely and individually injured by the proposed action, are not ready or willing to oppose it. Further, those who might oppose legislation, often have no notice that a given bill is pending.

It is also a marked feature of legislation that its makers are always sensitive to public opinion, and no body of law makers wants "to have a row kicked up" about anything they expect to do.

If the iron manufacturers, or the woolen mill owners, or sugar refiners see anything to be gained by promoting, or opposing legislation, they are at once watchful, and they have an organization which at once looks after their interests. But the public at large—the ninety and nine, who are out in the wilderness, and would be benefited or injured by the intended act, if only to a small degree, are not in a position to make themselves heard. If the Pacific railroads are to be helped or injured they speak out in meeting and are able to select a harbor on the coast regardless of the opposition of Senators, Representatives, and the authorized agents of the government, acting as advisers against reckless expenditure of money.

Rarely is the opposition to a scheme crystallized enough to present a bold front, and as in the last instance, even then sometimes it is helpless against something quiet, but forceful. If a city wants a harbor improved, it is not with it a question of intelligent study, and careful planning, for the city does not have to spend the money; but it is due to its numerical greatness that as much be spent on it as on some less favorably situated neighbor—and its friends cry out for their share—and get it, for the others are all silent—they might want something themselves some day.

If a city knows that something must at once be done with its sewage, and a tempting opportunity offers to plan a great undertaking—great because it will spend a large amount of money, larger than any other city has done, and make a show for those who manage it, and a cry is set up, it is done; because there is no organized opposition to show how much more it will cost than is stated at first, or to show that when done the plan will not work at all, not even in part without a large expenditure not foreseen, or not acknowledged in the beginning.

Again, a company undertakes to dig a long and expensive canal, and finds out that it has ludicrously underestimated its cost, and the difficulties in connection with it, and cannot make the money it thought it foresaw. It then attempts to unload on the government, although agents specially selected to examine and report to the legislature the facts render a clear adverse report, yet the company has strength enough to set aside this report, and comes forward with its unloading project, just the same—and there being no organized opposition, the thing looms up apparently as the wish of the nation. A canal is proposed in foreign soil, subject to the absolute control of that nation which has at any time the most formidable fleet, willy, nilly, when we have in our own territory railways enough to carry more freight in a week between our shores than the canal could carry in a year, and no shipping to use the canal when finished—and the press is silent.

It is supposed that the press represents the interests of the public, and always the better interests. Clearly, intelligence and honesty are needed to help us all, our pockets as well as our morals, against swindles, and even against mistakes of judgment as well. Clearly the public will welcome everything that logically protects it. Clearly no one can learn the many sides of a many-sided question unless those sides are turned around to the view. Everyone acknowledges that the last campaign was one of "education;" and the millions that listened, and read the varied arguments, shrieks, appeals, or what not that flashed before the eye, or deafened the ear, accepted the efforts to enlighten them, when honestly made.

Your journal has at times taken a high ground that should be maintained. It has at times opposed swindles fearlessly, it has at times in doubtful cases brought before the notice of the public the facts so as to enable a clear opinion to be formed as to possibilities, and as to probabilities. This should be continued, hence I get to the moral of my text, that you are wrong in that statement, which I noted above.

It is your duty as a representative of the best element of the engineering profession to examine and report critically, not only as editors, but as collecting opinions of the lights of the profession on the "ethics of projected plans" as well as other ethics. You should be prepared to hold such a position, even if at times you lose a few subscribers. Just at present there is no journal that passes critical judgments on proposed engineering schemes. It is true, no such judgment is infallible; but fair criticism is fair! I believe all attacks on the public purse should be examined by the press whether proposed in Congress, state or city.

There is no reasonable doubt that the Chicago Drainage Canal is wasteful, and bad in toto, and that the Berlin plan of land disposal could have been more cheaply, and more effectively applied there. There is no reasonable doubt that the Nicaragua Canal scheme is of no more advantage to the government than to a private party. There is no reasonable doubt that the improvement of the Mississippi River in the portion below St. Louis was wrong from the beginning, and would not have been carried so far as it has been, except that the South wanted its levees built, and the North silently allowed them to be built under the pretext of improvement of the river. There is no reasonable doubt that the improvement of the Missouri River consists simply in holding the ends of the railway bridges, by the government, and that the river never was, and never can be, improved for navigation.

Congress has stopped the mouths of the engineers, and when it lets them open occasionally, it pays no attention to them. Now every one of these "jobs," and such they are, could have been stopped by intelligent, and persistent opposition by an intelligent press. Unfortunately, in the past the New York press has lost its influence in such matters by simply shrieking and screaming against all river and harbor bills, as "jobs." Argument is fair, and intelligent selection will have effect, and you will pardon me if I advise you to hold a high ground, examine all schemes in the beginning, and oppose all bad ones.

You are so evidently right when you bring to notice all new devices, and methods in engineering; when you point out at times that this supposedly new process, or invention, or claim is an old one revamped, or is wrong in principle, that your system must save much wasted money; money that would be wasted. Legislation is frequently affected by clear intelligence of facts that are working public injury through public ignorance, and much public danger results from withholding the facts, through mistaken fear of injuring a lesser interest, while really preserving a larger.

For example, it seems clear to me that the whole system of "trolley roads" has run away with the public, and that a day of settlement is coming, and that we shall have the "readjustments" of all these roads in time, when the bonds come due. It seems plain to me that the earnings cannot possibly pay the fixed charges, when repairs are frequent, and it seems clear to me that the press has been too free in publishing its encouragement of all new roads, and claiming advantages that do not exist. It is true that the public will always have the roads; but is the public benefited in the long run by disastrous investments? I doubt it. I believe the subject of the cost, profits, and futures of all trolley roads are suitable subjects for comment.

It can do no harm to be so full; it will "free my mind," at any rate, and I may not feel compelled for another year to say anything to you. So I close. Yours truly,

Baltimore, Md., Jan. 24, 1897. R.

(Our correspondent's letter raises some interesting questions, all of which we cannot attempt to answer here. But his principal proposition, that a root evil in all our legislation is the fact that every legislator works for the interest of his particular locality instead of for the interest of the public at large, is a statement with which every candid observer must agree. The difficulty in remedying this evil is that the public does not appear to recognize it as an evil at all. So long as a Senator or Congressman looks out that his state or district gets "its share" of the appropriation for public works and of the appointments to public office, it matters little how much of the public funds he votes away.

Our correspondent is right also when he says that the press must be the chief reliance in exposing contemplated legislative extravagance and arousing public opinion against it. And yet what an ineffective reliance it is after all. Two cases come to our mind now in which prominent newspapers have lent their influence to urge a city into certain enterprises in which the owners of the newspapers were financially interested. Even when the newspaper press is honest, and we are glad to say that we believe this to be generally the case, it is seldom that its editors have sufficient knowledge to intelligently discuss engineering questions and pass judgment on engineering enterprises. Again, how seldom do we find a newspaper which will oppose a public expenditure that is to be made in its own city or state, even though it be a wholly unjustifiable expenditure of public funds?

We come now to the responsibility that our correspondent lays upon us, and we must frankly say that we cannot acknowledge it, at least to the

extent which his letter implies. It is indeed one of the purposes of this journal to critically discuss proposed engineering enterprises from the standpoint of the public interest. We have done this in the past and shall continue to do so in the future; but that after all is only a single one of the many departments of work which must be carried on by its editors, and it is manifestly impossible, in the limited time and space that can be given, for us to critically consider more than a very few of the many engineering enterprises that are all the time brought forward. Take the very case of the River and Harbor work, to which our correspondent especially refers. It would be as impossible for the editors to examine and form a judgment upon every separate project which is brought forward for a government appropriation every year as it is for Congress to do this. If these projects are to be sifted intelligently, the sifting must be done by the officers of the Corps of Engineers, who have direct charge of the work and are conversant with the local conditions. But after we have plainly pointed out the injury to the public interest which results from Congress usurping functions that belong to the executive officers of the government, our duty is done. Others must take up the work of agitating for a reform of this expensive absurdity.

Concerning our correspondent's comment on the Nicaragua Canal, it is fair to say that his letter was written before the publication of our notes on that subject in our issue of Jan. 24. We have no doubt that he and many of our readers were surprised to find that the report of the engineering commission has not been buried out of sight but is a very potent factor in the contest over the bill. We are inclined to believe, notwithstanding all that has been said concerning the lack of public appreciation of the engineering profession, that the public places more confidence in the opinions of engineers upon engineering questions than it does in the opinions of Congressmen.—Ed.)

THE HAMBURG-AMERICAN STEAMSHIP "PENNsylvania," which sailed from Belfast for New York on Jan. 30, is probably the largest freight carrier afloat. This ship was launched from the yard of Harland & Wolff, at Belfast, on Sept. 10, 1896. Her dimensions are as follows: Length on deck, 585 ft.; beam, 62 ft.; depth from keel to awning deck, 42 ft.; her displacement is about 23,400 tons; her dead weight capacity is 13,500 tons, and she will take about 19,000 tons measurement cargo. She is equipped with two quadruple expansion engines of 6,000 I HP., and the hull is divided into 12 water-tight compartments, without any communication below the water line. The "Pennsylvania" can accommodate 200 first-cabin, 150 second-cabin and 1,000 steerage passengers. On her trial trip the ship made an average of 14½ knots per hour, or ½ knot more than the contract speed. She is, of course, a freight carrier, and not an "ocean grayhound."

THE CASCADE TUNNEL of the Great Northern Ry. is reported to have been commenced, Mr. H. C. Henry, of Seattle, Wash., having the contract for the approaches. The tunnel will be 13,283 ft. long, with a down grade westward of 1.7%, and its cost is estimated at $2,000,000. It will take the place of the present switchback line over the range, as described in our issue of May 18, 1893.

WATER POWER DEVELOPMENT AT ST. MARY'S FALLS.

The possibility of utilizing the 18-ft. fall in the St. Mary's River at Sault Ste. Marie, Mich., for developing water power has long been recognized and various different attempts have been made in the past to organize and carry out a broad plan of utilization. None of these plans reached a very advanced stage on the American side of the falls until very recently, but on the Canadian side considerable progress has been made during the last three or four years. As some of the daily newspapers of the West have recently come out with more or less reckless statements regarding the extent of this work, which have excited undue attention on the part of engineers and contractors looking for employment, it seems desirable to state briefly just what has been done and what it is proposed to do in the near future.

Some years ago the town of Sault Ste. Marie, Ontario, commenced efforts to develop water power from the St. Mary's Falls, near the present site of the Canadian Ship Locks (Eng. News, 1894) and considerable work was done. The town, however, was unable to raise the money necessary to carry the work to conclusion, and some three years ago sold its interest to a syndicate of Eastern capitalists who incorporated the Lake Superior Power Co. On the Canadian side of the river this company has constructed a canal about 2,000 ft. long, 125 ft. wide and 14 ft. deep, which furnishes power to the Water & Light Co., supplying water and electric light to the town; to the Algoma Iron Works, and to the Sault Pulp & Paper Co. The last named company now operates one mill known as Mill No. 1, and is constructing a second mill known as Mill No. 2.

Mill No. 1 of the Sault Pulp & Paper Co. is operated by 22 turbines of the new American type, 51 ins. diameter, 300 HP.; 18 of these turbines furnish power for operating the pulp-grinders, 2 furnish power for the wood room, and 2 furnish power for water and light purposes. This mill turns out 150 tons of pulp per 24 hours, and also furnishes power for operating the Lake Superior Carbide Works, located on the American side, but owned by the same company. Mill No. 2 is in process of construction, and is to be a paper and pulp mill. The foundation work is completed and the masonry finished up to the second floor. The turbines, 20 in number, are all placed. These turbines are of the McCormick type, and each is 51 ins. in diameter and of 300 HP. The combined turbine plants of the two mills have a capacity of 12,600 HP.

In the summer of 1896 the Sault Pulp & Paper Co. purchased the old water power rights on the American side of the river and is now preparing plans and estimates for a development of 50,000 HP. It is expected that these plans will be completed by Feb. 15. The projected canal will be three miles long, 300 ft. wide and 20 ft. deep, and the velocity of flow will be 5 ft. per second. The location and test borings have been made and some dredging done on the intake channel.

In connection with this development of power a number of corporations are starting work. The Lake Superior Pulp & Paper Co. has purchased several tracts of pulp timber land, and is now clearing a tract of 36 square miles from which it expects to cut about 60,000 cords of pulp wood. This company is also said to be contemplating the installation on the Canadian side of the river of an electric reduction plant for iron ore and gold. The Niagara Pulp & Paper Co. has also purchased from the Canadian Government the pulp wood on ten townships of land at the foot of Lake Superior, and is now extensively operating at Batchewana Bay. A cord of wood makes a ton of pulp, and the Canadian Government sells the stumpage of the pulp wood at 20 cts. per acre, but the purchaser must not cut any other timber.

In a future issue it is expected to describe in more detail the water power development at St. Mary's Falls. The present statement is made simply to correct an impression which has got abroad that the work is now demanding large numbers of laborers. We are indebted to Mr. J. L. Gallard, U. S. Assistant Engineer, Sault Ste. Marie, Mich., for much of the information presented here.

THE GAS EXPOSITION.

The Gas Exposition which opened last week at the Madison Square Garden, New York city, was a most attractive and instructive exhibition of the place which gas still holds as an agent for lighting, cooking and furnishing power, even in this age of electricity. No novelties of any great importance to engineers were observed, but the exhibition was a fine school of instruction for those who wished to find how gas is made by modern methods, how it is tested and measured, and how it may be used with economy. A most imposing exhibit of a complete water-gas plant was made by the United Gas Improvement Co., of Philadelphia. It was a full-sized generating plant of a capacity of 250,000 cu. ft. of gas per day, with miniatures of the subsidiary apparatus, such as gas holder, exhauster, and engine, purifier, station meter, governor, etc. It also included a complete outfit for analyzing gas, photometers, etc.

R. D. Wood & Co., Philadelphia, showed the Taylor gas producer and made quite a display of gas works machinery and fittings. Gas works machinery and supplies were also shown by the Continental Iron Works, Brooklyn, N. Y.; Barrett, Hayward & Co., Baltimore, Md.; and the Lidell-Porter Co., Newark, N. J.

Steam boilers were represented by the Heine Safety Boiler Co., of St. Louis. The Pintsch system of lighting by compressed gas, for railway cars, buoys, etc., was shown by the Safety Car Heating and Lighting Co., 160 Broadway, New York. Gas exhausters were shown by the well-known makers of fans, blowers, etc., B. F. Sturtevant Co., Boston; Wilbraham Baker Blower Co., Philadelphia, and P. H. & F. M. Roots Co., Connersville, Ind.

In gas lighting the honors of the exhibition were carried off by the Welsbach light, which was shown in a great variety of forms all over the building. The light seems to have become a formidable competitor of electric lighting. Agencies are said to have been established in every town and city of the United States, but if any of our readers has failed to have seen or heard of this light he can obtain full particulars from the parent company, the Welsbach Commercial Co., Philadelphia.

A number of exhibitors showed devices for reducing gas lighting bills, such as pressure regulators, improved burners, etc. Gas piping, valves, fittings, etc., were shown by a number of makers.

Gas machines for making gas in moderate quantities from naphtha or gasoline were shown by the Pennsylvania Globe Gas Light Co., Philadelphia.

For measuring gas several meter manufacturing companies showed their meters in various sizes, with sectional models showing their methods of operation; also meter provers which are used by gas companies to prove to their customers that their meters tell the truth. Prepayment meters were shown by some of the meter companies. These are a somewhat recent invention which applies the "nickel in the slot" principle to the gas meter. The coin dropped in the slot detaches a stop in the mechanism and allows the meter to operate in the usual way. When the registering mechanism has made a definite number of turns, corresponding to the amount of gas paid for by the coin, the gas is shut off until another coin is paid. The mechanism is quite simple and together with the locked coin box is all enclosed in a box attached to the side of an ordinary meter. Gas and gasoline engines were shown in considerable number, but they were not as numerous as might have been expected. We noted especially an engine built by the New Era Iron Works, of Dayton, O., which was running an electric light dynamo and furnishing lights to an illuminated sign. The dynamo was built by the Fort Wayne Electric Corporation, Fort Wayne, Ind. Another gas engine was shown by Fairbanks, Morse & Co., of Chicago. Both of these engines have good features and are well designed, but they are not essentially different from the engines of other well-known makers.

Gas and oil stoves, heaters, ranges, boilers, occupied more space than any other class of article in the exhibition. They were shown by a great number of makers, and in an extraordinary variety of shapes, styles and decorations. From the amount of sculptured ornamentation put on some of these stoves, apparently to hide their intrinsic ugliness of form, it would appear that the chief item of expense in a factory making such stoves would be the salaries of designers, pattern-makers and others concerned in the perfecting of the ornamentation. Nothing really novel in this department was seen, if we may except what was called an "odorless sanitary combustion of gaseous fuel," shown by a certain "Odorless Gas Stove Co." The novelty seemed to consist in burning the gas under a cast-iron hood which becomes red hot and radiates its heat into the room, and the injection of water, drop by drop, into the air supplied to burn the gas. About eight grains of water to the cubic foot of air is said to be the proportion added, and according to the pamphlet describing the stove, the water is decomposed into free oxygen and hydrogen gas, the latter serving as fuel in conjunction with the gas while the former is set free as an atmospheric vitalizing agent. With such unscientific rubbish in the pamphlet

it is not surprising that it also claims for the stove a gain of over 400% realized from a given volume of gas. The stove is no doubt a good enough one, but the method used in advertising it is highly objectionable.

A useful attachment for oil and gas stoves is an "asbestos heat retaining oven," constructed of an under wall of sheet iron and an outer wall of asbestos, with an air space between. It was made by the Ohio Oven & Japan Co., Cincinnati, O.

BRIDGE ACCIDENTS IN THE UNITED STATES AND CANADA IN 1896.

By Charles F. Stowell, M. Am. Soc. C. E.

Tabular statements of bridge accidents in the United States and Canada during 1896 have been compiled by the writer, and are presented herewith. These lists do not include a considerable number of wooden bridges which were burned but the fire discovered in time to prevent any further accident, nor do they cover an extremely long list of bridges carried away by floods, nor several bridges blown down without other damage to person or property.

The list of railroad bridge accidents comprises 37 items on 33 different roads, causing a loss of 57 lives and injuring 86 more. Of the structures involved, 8 were wooden trestles, 7 iron or steel bridges, 9 wooden bridges and 13 of unknown construction; 14 of these bridges were knocked down, 5 were "square falls," 6 were destroyed by fire, 5 by freshets, the cause of the accident in 3 cases was unknown, and in 1 case the bridge was a Howe truss draw-span which gave way in consequence of the breaking of the wire lifting cables. The worst accident was the one on Dec. 7 at the Cahaba river bridge in Alabama, where the rails had been removed by train wreckers, causing a derailment resulting in the destruction of the bridge.

On electric railways there were six bridge accidents on five roads, causing a loss of 46 lives and injury to 9 others. The latter figures are probably too low. Of the bridges involved, one was a wooden trestle, one a stone arch bridge and four were iron or steel trusses. Five of the accidents were "square falls," and in one case a bridge was knocked down by a derailed car.

The highway bridge accidents number 59, involving a loss of 14 lives and injury to 50 persons. Two of the bridges which fell were stone arches, 2 were wire suspension bridges, 3 were iron or steel trusses (one of which was damaged but did not fall), 44 were wooden bridges and 8 were of unknown construction. One of the stone bridges fell without any load, but just after a team had passed, and the other tumbled down while men were at work removing it. The suspension bridges both succumbed to crowds of people, one crowd watching a fire in the neighborhood and the other returning from church. Of the iron bridges which fell, the one over the Erie canal at Fort Plain, N. Y., was an ancient cast-iron affair, which broke down under an omnibus load of people returning from a railroad station and a drove of cattle, which was met on the bridge. The iron bridge which broke down at Brant Center, Ill., on Sept. 23 was a new one, having been finished only two days before. It went down with a team drawing a load of produce, said to weigh about a ton. The details of construction and name of the builder of this interesting structure are not accessible. The 44 wooden bridges which gave up the ghost were of all sizes and ages, but mostly very old and rotten. One of them, however (the one at Ensley, City, Ala., which fell down on Nov 22), was new, and had been in use only a few days. It broke down with a load of people returning from a picnic. Some of these wooden bridges fell down without any load on them, and apparently because they had become discouraged, while the loads which wrecked the others varied all the way from a single darky to a six-horse team and load. One bridge, at Tamworth, Ont., is interesting. A bridge at the same spot fell down eight years ago with a cow. They made the new bridge stronger, so that it held up eight years and took a load of wood to break it down. The builders will doubtless do even better next time. The threshing machine and the portable engine for running it are particularly fatal to country bridges, no less than ten having been wrecked by them during the past year.

It appears from these tables that July is the most dangerous month to cross a bridge, 19 having gone down then, and that June is the safest month, only 4 accidents being credited to that month.

Bridge Accidents in 1896.—Table I.—Railway Bridges.

Date.	Name of road.	Location of bridge.	Kind of bridge.	Cause, accident.	Kil'd.	Inj'r'd.
Jan. 7.	Louisville & Nashville	Rigolets, La.	Iron	Knocked down	..	..
Jan. 14.	Allegheny Valley	Kittanning, Pa.	Wooden	Knocked down	..	..
Jan. 21.	Baltimore & Ohio	Foley, Pa.	Iron	Knocked down	..	..
Jan. 31.	C., C., C. & St. L.	Lawrenceburg Junc., Ind.	Iron	Knocked down	2	3
Feb. 5.	At., Top. & Santa Fe	Yarborough, Tex.	Unknown	Unknown	..	..
Feb. 6.	New York & New England	Bristol, Conn.	Wooden	Repairing	7	..
Feb. 24.	Oregon R. & N. Co.	Pendleton, Ore.	Wooden	Fire	..	..
Mar. 4.	Southern Railway	Spartanburg, S. C.	Unknown	Knocked down	1	..
Mar. 31.	Denver & Rio Grande	Lumberton, N. Mex.	Wooden	Fire	..	..
Apr. 1.	Georgia & Alabama	Lumpkin, Ga.	Wooden trestle	Fire	..	2
Apr. 7.	Wheel. & Lake Erie	Toledo, O.	Unknown	Square fall	1	1
Apr. 11.	Old Colony	Boston, Mass.	Wooden	[1]	..	..
Apr. 13.	Bedford Belt	Bedford Junct., Ind.	Wooden trestle	Repairing	6	1
Apr. 13.	Missouri Pacific	Herman, Mo.	Iron	Knocked down	..	3
Apr. 14.	New Orleans & N. E.	Vosburg, Miss.	Wooden trestle	Freshet	..	11
May 3.	Hous., E. & W. Texas	Livingston, Tex.	Unknown	Unknown	1	..
May 16.	St. Louis & S. F.	Carthage, Mo.	Unknown	Freshet	..	2
June 6.	Norfolk & Western	Bedford City, Mo.	Wooden trestle	Knocked down	..	..
July 3.	Peoria, Decatur & Evansv.	Newton, Ill.	Wooden trestle	Knocked down	..	1
July 14.	Wisconsin Central	Oshkosh, Wis.	Unknown	Knocked down	..	1
July 21.	Chicago & Texas	Murpheysboro, Ill.	Wooden trestle	Freshet	..	15
July 24.	Missouri Pacific	Lamar, Mo.	Unknown	Knocked down	1	..
July 26.	Balt. & O. Southwestern	Salem, Ill.	Wooden trestle	Knocked down	..	2
July 29.	Terre Haute & Indianapolis	Darlington, Ind.	Iron	[2]Freshet	3	2
Aug. 2.	Southern Railway	Durham, N. C.	Wooden	Fire	..	2
Aug. 5.	Baltimore & Ohio	McMechen, W. Va.	Unknown	Repairing	1	2
Aug. 13.	Cin., Jack. & Mack.	Hudson, Mich.	Wooden trestle	Square fall	..	..
Sept. 3.	Northern Pacific	Sappington, Mont.	Unknown	Freshet	..	..
Sept. 8.	K. C., Osceola & Southern	Clinton, Mo.	Wooden	[3]Fire	2	..
Sept. 13.	Arcata & Mad River	Eureka, Cal.	Wooden	Square fall	4	24
Sept. 22.	Toledo, Peoria & Western	La Harpe, Ill.	Unknown	Square fall	..	..
Oct. 6.	Missouri, Kansas & Texas	Ft. Worth, Tex.	Unknown	Knocked down	..	3
Oct. 20.	Central of New Jersey	Dover, N. J.	Iron	[4]Knocked down	..	..
Oct. 21.	Chicago Great Western	Leavenworth, Kan.	Unknown	Square fall	3	..
Oct. 23.	Denver & Rio Grande	Saperino, Cal.	Wood	Fire	1	..
Dec. 3.	Chic., Burl. & Quincy	Coin, Ia.	Unknown	Unknown	..	..
Dec. 7.	Alabama Mineral	Cahaba River	Iron	Knocked down	24	11
	Total				57	86

[1] This was a Howe truss drawbridge, which failed by lifting cables breaking. No train on it.
[2] Supports of this bridge had been undermined by freshet and engine was sent over to see if it was safe.
[3] This bridge was on fire and fire engine was run out on it, when it fell.
[4] Drawbridge—was run into by train while raised to let boat pass.

Bridge Accidents in 1896.—Table II.—Bridges on Electric Railways.

Date.	Name of road.	Location of bridge.	Kind of bridge.	Cause, accident.	Kil'd.	Inj'r'd.
Jan. 9.	Akron, Bedford & Cleveland.	Bedford, O.	Iron	Square fall	2	1
Feb. 11.	Akron, Bedford & Cleveland.	Bedford, O.	Wooden trestle	Square fall	1	7
Apr. 7.	Rapid Railway	Mt. Clemens, Mich.	Iron	Square fall	..	1
May 26.	Consolidated Electric	Victoria, B. C.	Iron	Square fall	43	..
June 15.	..	Muskegon, Mich.	Stone	Square fall	..	..
July 1.	Dayton Traction Co.	Alexandersville, O.	Iron	Knocked down	..	..
	Total				46	9

Bridge Accidents in 1896.—Table III.—Highway Bridges.

Date.	Location.	Kind of bridge.	Kind of accident.	Cause.	Kil'd.	Inj'r'd.
Jan. 30.	Augusta, Wis.	Unknown	Square fall	Load of logs	..	1
Feb. 6.	Jones' Mills, Pa.	Unknown	Square fall	Load of lumber	..	..
Feb. 22.	Seneca Falls, N. Y. State Canal.	Wooden	Square fall	Load of stone	..	..
Mar. 1.	Hund's Station, Kan.	Wooden	Square fall	Horse and carriage	..	..
Mar. 7.	Chilesburg, Va.	Wooden	Square fall	Four-mule team and load	..	..
Mar. 9.	Tamworth, Ont.	Wooden	Square fall	Load of wood	..	1
Mar. 24.	Granada, Colo.	Unknown	Square fall	Thresh'g machine engine	2	..
Mar. 29.	Weston, W. Va.	Wire suspension	Square fall	Crowd watching fire	..	2
Mar. 30.	Terrell, Tex.	Wooden	Square fall	Man on horseback	..	1
Mar. 30.	Shamokin, Pa.	Wooden	Square fall	Horse and wagon	..	1
Apr. 1.	Flemington, N. J.	[1]Stone arch	Square fall	Fell without load	..	..
Apr. 14.	Westtown Station, Pa.	Wooden	Square fall	Traction engine	..	..
Apr. 20.	Camden, N. Y.	Wooden	Square fall	Load of wood	..	1
Apr. 21.	Butler, Ala.	Wooden	Square fall	Negro walking across	..	..
Apr. 21.	Great Bend, Pa.	Wooden	Square fall	Horse and wagon	..	..
May 4.	Toronto, Ont.	Wooden	Square fall	Man leading horse	..	1
May 7.	Rochester, Minn.	Wooden	Square fall	Team had just crossed	..	..
May 7.	Florence, Ala.	Wooden	Square fall	Fell without load	..	..
May 8.	Cohoes, N. Y.	Stone arch	Square fall	Fell while taking down	1	..
May 11.	Fort Plain, N. Y.—Erie Canal	Iron	Square fall	Omnibus and cattle	..	1
June 3.	Canastota, N. Y—State ditch	Wooden	Square fall	Load of wood	..	1
June 30.	Hancock, Md.	Wooden	Square fall	Load of bark	1	..
July 2.	Greensburg, Pa.	Wooden	Square fall	Horse and carriage	..	1
July 2.	Dallas, Tex.	Wooden	Square fall	Six-horse team	..	1
July 7.	Cozad, Neb.	Wooden	Square fall	Steam threshing machine	..	2
July 10.	Witbeck Mills, Mich.	Wooden	Square fall	Load of shingles	..	1
July 13.	Carthage, N. Y.	Wooden	Square fall	Load of lumber	..	1
July 13.	Canton, O.	Wooden	Square fall	Traction engine	1	1
July 15.	Odin, Ill.	Unknown	Square fall	Thresh'g machine engine	1	..
July 16.	Marion, Ind.	Wooden	Square fall	Loaded wagon	..	..
July 18.	Chester, Pa.	Wooden	Square fall	Loaded wagon	..	..
July 18.	Warrensburg, Mo.	Wooden	Square fall	Horse and carriage	..	..
July 30.	Marshall, Mo.	Wooden	Square fall	Undergoing repairs	1	..
July 31.	Cornwall, Ont.	Wooden	Square fall	Herd of cattle	..	..
Aug. 6.	Gowanda, N. Y.	Wooden	Square fall	Loaded wagon	..	1
Aug. 6.	Leavenworth, Kan.	Wooden	Square fall	Threshing machine	..	..
Aug. 6.	Keene Valley, N. Y.	Wooden	Square fall	Horse and wagon	..	..
Aug. 10.	Fort Plain, N. Y.	Wooden	Square fall	Fell without load.	..	..
Aug. 12.	Laingsburg, Mich.	Wooden	Square fall	Threshing machine	1	3
Aug. 19.	Turlock, Cal.	Wooden	Square fall	Herd of cattle	..	..
Aug. 24.	Goshen, N. Y.	Wooden	Weakened.[2]	Load of hay	..	..
Aug. 29.	Burnhamthorpe, Ont.	Unknown	Square fall	Herd of cattle	..	..
Aug. 29.	Eugene, Colo.	Wooden	Square fall	Load of machinery	..	..
Sept. 4.	Rome City, Ind.	Wooden	Square fall	Load of stone	..	1
Sept. 11.	Camden, Ark.	Wooden	Square fall	Bridge being erected	..	2
Sept. 13.	Woodworth, Wis.	Wooden	Square fall	Horse and carriage	..	..
Sept. 14.	Sanford's Corners, Mich.	Wooden	Square fall	Thresh'g machine engine	..	1
Sept. 16.	Dawsonville, Ga.	Wooden	Square fall	Undergoing repairs	2	3
Aug. 23.	Brant Center, Ill.	Iron	Square fall	Team and wagon	..	..
Sept. 29.	Fremont, Neb.	Wooden	Square fall	Team and wagon	..	..
Oct. 22.	Woodbury county, Ia.	Unknown	Square fall	Threshing machine	..	2
Nov. 1.	Urichsville, O.	Unknown	Square fall	Political parade	..	1
Nov. 11.	Milton, Ore.	Wooden	Square fall	Fell without load	..	..
Nov. 18.	Council Bluffs, Ia.	Iron	..	Road roller[3]	..	..
Nov. 18.	Pine Bluff, Ark.	Wooden	Square fall	Four-horse team and load	1	..
Nov. 22.	Ensley City, Ala.	Wooden	Square fall	Wagon load of people	1	11
Dec. 14.	White Rock, Colo.	Wooden	Square fall	Traction engine	..	..
Dec. 17.	St. Lawrence county, N. Y.	Wooden	Weakened.[4]	Horse and carriage	..	1
Dec. 21.	Littleton, W. Va.	Wire suspension	Square fall	Crowd of people.	2	7
	Total				14	50

[1] Of three spans. [2] By a freshet. [3] A heavy road roller was run over this bridge, cracking the stringers and doing other damage, but the bridge did not fall. [4] By a flood.

DEFECTS IN STEAM BOILERS.

(With two-page engraving.)

The Austrian Society of Engineers and Architects several years ago appointed a committee to make an investigation of the subject of defects in steam boilers, their causes, consequences and methods of repair and prevention. The first report of that committee was made in 1891, and related to the defects of locomotive and portable boilers. The second report related to stationary boilers and is in the form of a quarto pamphlet of 49 pages of text, profusely illustrated, and 13 plates of photogravures. It is entitled "Schaden an Dampfkesseln. Heft II., Schaden an Stabilkesseln." The pamphlet is an excellent contribution to the literature of steam boilers, and is a fine example of what good work may be accomplished by a research committee of an engineering society when it takes plenty of time and infinite pains. Many of the forms of boilers shown in the report are unknown in American practice, some of them being survivals of ancient types which were never used here and are going out of use in Europe, while others are complicated new constructions, evidences of a transition stage of engineering in which the new forms of construction are apt to be more notable for their variety than for their excellence. Much of the material in the report, however, contains information which applies to the types of boilers built in this country. We have abstracted from the report those portions which we believe to be of most general interest, and have had them translated by Mr. O. J. Marstrand, M. Am. Soc. C. E. The defects are considered under the following heads: I. Change of Shape. II. Corrosions. III. Scratches, Cracks and Imperfections of Material. Examples of all of these kinds of defects, taken from photographs, are given in our inset sheet. We begin our extracts from the text with the subject of Corrosion; each extract being accompanied with a cut.

I.—External Corrosion. Figs. 1 to 6.

Fig. 1.—Local rust, spreading itself in tongue shapes over large surfaces.

Location.—Exterior surfaces of boiler, in places where the masonry forming the fire and draft passages touches the boiler shell.

Cause.—Water absorbed by the masonry. When the boiler is not steaming, water is condensed upon the lower drums, runs down, and gathers on the sides where the wall is built in against the drum.

Consequences.—Gradual destruction of such places; dangerous because the adjoining masonry makes inspection difficult.

Prevention.—Use clay mortar instead of lime mortar at these places; finishing by inserting a layer of asbestos; insertion of iron plates between wall and drum; draining of the bottom flue by deep drain pipes and water-seal. Frequent drying out of the flue by heat is recommended.

Fig. 2.—Rust on the plate-edges and rivet-heads.

Location.—On the first seams of the plates, but at a greater or less extent on all, and especially on inaccessible parts of the exterior surface of the boiler.

Cause.—In using very sulphurous coal there will be formed by its combustion both sulphurous acid, SO_2, and sulphuric anhydride acid, SO_3, which is changed by water vapor into sulphuric acid, H_2SO_4. Such vapor is made when the hot cinders are extinguished under the grate. There is an accumulation of this acid in the non-conducting covering of the exterior surface of the boiler, at the seams. The presence of lime in the boiler covering, however, neutralizes the acid and acts as a preventative of corrosion.

Consequences.—Soot and other ingredients of the coating on the exterior surfaces absorb the sulphuric anhydride, which is harmless, when the outside of the drum is dry; on cooling however, it absorbs water from the air and is changed into sulphuric acid, which is corrosive. Weakening of the seams and plates, often dangerous at places which escape cleaning and examination.

Prevention.—Brushing the exterior surfaces of the drum before it is cooled. Drawing the cinders out of the ash pit before quenching them.

Fig. 3.—Rust on the plate joints.

Location.—Especially on the parts of the drum in the fire passages.

Cause.—The sulphuric acid, formed as stated above, acts to destroy the plate, especially when small leaks are present in the seams.

Consequence.—The corrosion in such places is much more rapid than ordinary rusting.

Prevention.—Immediate calking of leaky seams.

Fig. 4.—Rust on circular seams and in corners.

Location.—On the circular and longitudinal seams (less frequently on the seams) of the lower drum and on the bottom course of the outer shell of the fire tube boilers.

Cause.—Small leaks in the seams in the second or third fire passage where the flue gases are so cooled that they do not evaporate the accumulated moisture on the plate.

Consequence.—When limited to a small part of the circumference, not adjoining a point of support of the boiler, the rust may accumulate to several millimeters in depth without becoming dangerous. The calked edge of the seam is destroyed in such places; by continual leaking the shanks of the rivets will also be considerably corroded.

Prevention.—Careful riveting. Frequent inspection of these places, especially the rear parts of the under side of the drum, and all the intersections of the circular and longitudinal seams where the latter form a gathering place for moisture. Quick cooling of the boiler is to be avoided. Leaky seams should be calked immediately.

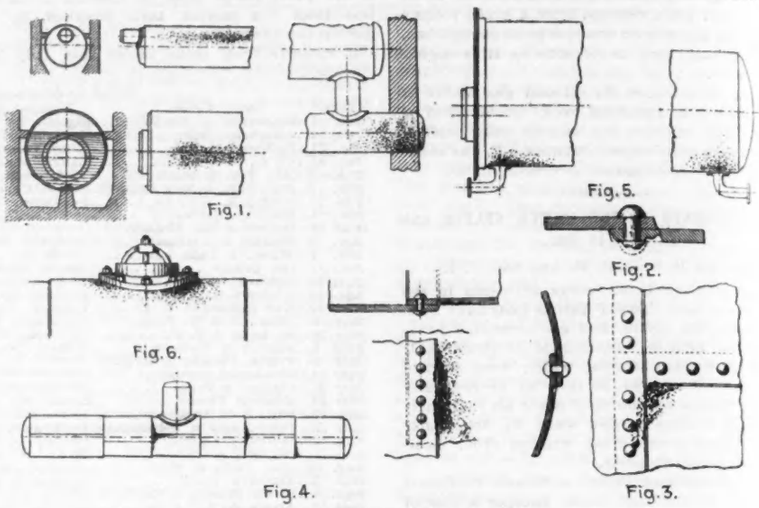
Fig. 5.—Rust at the edges of flanges joined to the boiler plates by bolts.

Location.—In places where the cast-iron flanges of the steam-pipe and feed-pipe are fastened to the drum.

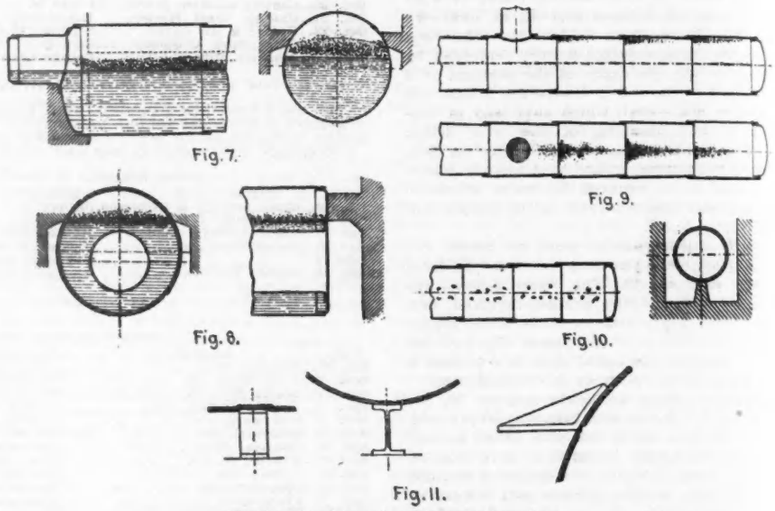
Cause.—Badly-fitting flanges. Defective riveting at parts which are difficult to reach.

Consequence.—These places are difficult to inspect and are exposed to extensive corrosions on account of the surrounding masonry which spreads the moisture.

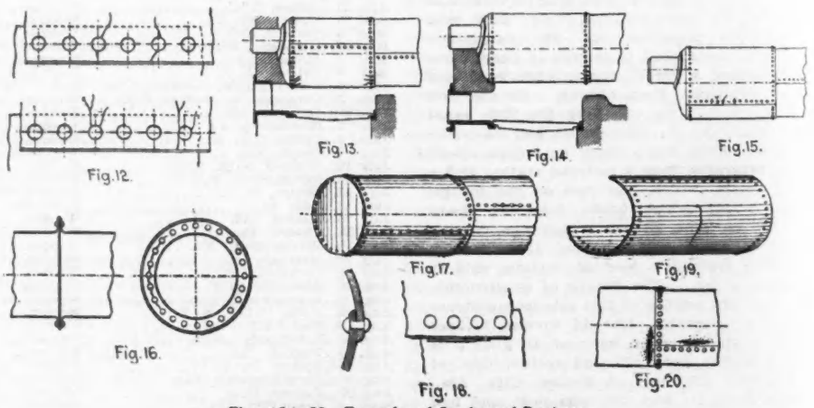
Prevention.—Flanges which are curved to fit the round-



Figs. 1 to 6. Examples of External Corrosion.



Figs. 7 to 11.—Examples of Internal Corrosion.



Figs. 12 to 20.—Examples of Cracks and Ruptures.

SOME TYPICAL DEFECTS IN STEAM BOILERS.

Collected by a Committee of the Austrian Society of Engineers and Architects.

ing of the drum are to be carefully made and should be furnished with a wrought-iron packing ring.

Fig. 6.—Same kind of corrosion as shown in Fig. 5.

Location.—In places where flanges of cast-iron manhole frames are fastened to the boiler plates.

Cause.—Leakage, from defective riveting and calking of the flange.

Consequence.—Dangerous when extended over large surfaces, the process being favored by concealment by the masonry.

Prevention.—Cast-iron manhole frames are to be exactly worked and fitted and provided with packing rings. The riveting is to be kept clear of the masonry.

II.—Internal Corrosion. Figs. 7 to 11.

Fig. 7.—Burning of surfaces at the water level.

Location.—On the upper drum, immediately above the water level.

Cause.—Bad fitting of the masonry in the smoke passages, or the roof of the flame passages being placed too high in relation to the low water level, whereby the dry boiler plates are continually exposed to the fire.

Consequence.—The resulting corrosion produces, in a plane parallel to the longitudinal axis, dangerous weakening of the material which extends along the plates at the height of the water level. The plates are burned out and fall off on the inside as scales.

Prevention.—The top of the smoke passage must be 10 centimeters (4 ins.) below the low water level. The masonry is to be built with an upright course, cut to suit the curvature of the drum.

The limit-line for the masonry ought to be painted on the boiler by the maker.

Fig. 8.—Similar to Fig. 7.

Location.—On the rear drum head, especially in fire-tube and water-tube boilers.

Cause.—Bad fitting of the masonry to the end of the drum, whereby this part of the boiler is heated at places where it is not in contact with water.

Consequence.—Dangerous weakening of the material in a place where it is most yielding.

Prevention.—Sound and well-fitting brickwork at the rear head of the drum.

Fig. 9.—Burning away in the upper side of the water drum.

Location.—When too little inclination is given to the upper side of the lower drum, or when, by telescopic arrangement of the courses, the inside lap is placed in such a direction that it will trap or pocket the steam.

Cause.—Obstruction to the escape of the steam due to too slight inclination or to a projecting edge of the plate. There are formed tongue-shaped coatings on the surfaces which are much heated by the gases and by the radiation from the neighboring masonry.

Consequence.—The burning away of the plates, when limited to small surfaces, is not very dangerous. By longer-continued action the material is destroyed.

Prevent.on.—Proper arrangement of the rings and sufficient inclination of the lower drum (at least 1-50 of the length.)

Fig. 10.—Pittings or groovings on the inside of the boiler.

Location.—In places where drums rest on the masonry along the whole length.

Cause.—Alternate heating and cooling through variable feeding when the end of the feed-tube is too close to the metal of the boiler. Low temperature of the metal at this point which favors a longer retention of gases absorbed in the water (lack of circulation in the water).

Consequence.—The appearance of numerous corrosions which extend ribbon-shaped along the under side of the drum necessitates often the replacing of all the bottom plates or the complete renewal of the drum.

Prevention.—Drums resting upon masonry between the smoke passages are to be avoided.

Fig. 11.—Furrow-shaped corrosions on the inside of the boiler.

Location.—On places pressed inward, as above the supporting columns, behind the bearers, and under the upright tubes, especially on the cooler drums.

Cause.—Strains in the material resulting from the weight and the temperature changes.

Consequence.—As a rule, not dangerous, when discovered in time.

Prevention.—Suitable supports; protection of the corroded parts.

III.—Cracks and Ruptures. Figs. 12 to 20.

Fig. 12.—Cracks entending from the rivet holes.

1, single; 2, branched.

Location.—Cracks at the rivet holes which already have been formed during the manufacture may occur in any rivet seam. The formation of cracks at the rivet holes during the use of the boiler occurs especially on the parts exposed to the flame; more frequently at the round seams than at the longitudinal.

Cause.—Defective material; too hard metal; red-short or cold-short and badly-welded iron; defective manufacturing; badly-punched plates; holes not fitting and strained by use of a drift-pin; sudden changes in temperature.

Consequence.—A few short cracks at the rivet holes may lead to no further results; several cracks diminish the strength of the rivet seams. Long cracks produce leaks. Sudden bursting may occur. Rivet holes in parts under tension tear open and are on that account more dangerous than rivet holes in parts under compression where the cracks tend to close themselves.

Prevention.—Rivet holes are, when possible, to be drilled at the same time through both plates, after these are bent and fitted together.

Punching of the plates must be done with well-fitting, sharp dies, and the holes must be punched about 20% too small and then reamed out. Where burrs occur they must be cut off and the holes countersunk. Short cracks must be repaired by calking; long cracks by drilling a hole through the end of the crack and driving a rivet with a large head.

Fig. 13.—Similar to Fig 12.

Location.—In cylindrical boilers on the lower and unprotected half of the drumhead.

Cause.—The inflow of cold air, when the fire-door is open. The outside of the plate is more cooled than the inside and, therefore, contracts more. The alternate expansion and contraction of the material produces cracks.

Consequence.—The presence of numerous cracks in the rivet holes and the edges destroys the strength of the seam, which becomes leaky.

Prevention.—The first round seam must be sufficiently protected by the masonry. Closing of the damper before

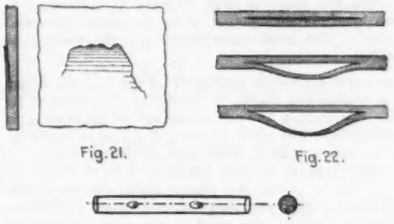


Fig. 21. Fig. 22.

Fig. 23.

Figs. 21 to 23.—Examples of Faulty Material in Steam Boilers.

opening the fire-door. Open windows or doors immediately in front of the fire-doors should be avoided.

Fig. 14.—Single, short cracks at the rivet holes in the round seams.

Location.—On the first round seam near the fire-bridge where it is exposed to the direct attack of the flame, as well by external as by internal firing.

Cause.—The flame causes superheating and considerable local strain. Badly-fitting rivet holes and rivets, whereby strains are set up in the material, favors the production of cracks.

Consequence.—The appearence of leaks as soon as the crack extends beyond the rivet head (long cracks). At first incrustation at the crack is noticed, then penetration of moisture, and finally, by larger leaks, streams of water.

Prevention.—The arrangement of round seams in the immediate neighborhood of the fire-bridge (especially immediately behind it) is to be avoided. Patching the fire-plates which are cracked at the rivet holes is not to be recommended. Such fire-plates should be renewed.

Fig. 15.—Cracks at the rivet holes in the longitudinal seams.

Location.—In long drum and in fire-tubes on the longitudinal seams above the grate.

Cause.—Superheating of the longitudinal seam by the flame and the radiation from the adjacent hot masonry, when external firing is used. Also, in fire-tubes, on account of superheating of the longitudinal seam by contact of the flame and the boiler plates, the conductivity of heat at the lap seam being decreased, and the outer plate cooled by the inflowing air.

Consequence.—Opening of the calked seam and leak in the riveting.

Prevention.—Suitable arrangement of the longitudinal seams. In internal flues these seams should always be below the grate-plate. The use of welded corrugated tubes in the first two courses is recommended. In externally-heated upper drums only that longitudinal seam, the outer lap which extends upwards, must be exposed to the fire and in such a way that it does not come too close to the masonry; the diametrically opposite seam must be protected by the covering.

Fig. 16.—Long cracks extending through several rivet holes.

Location.—In the circular seams of fire-tubes connected by flanges or by lap joints. Also in the round seams which connect the fire-tube to the end of the drum.

Cause.—Badly-made seams; the absence of a packing ring; too great spacing of the rivets and hard material; finally, on account of great pressure of the tube on the yielding bottom, and defective calking of the seam; over-calking of the packing ring.

Consequence.—The occurrence of large leaks; progressive lengthening of the crack. Breaking loose of the tube is to be feared.

Prevention.—The rivet holes are to be drilled, when the plates are curved and well-fitted together. By the riveting of the circular seams the rivets must be very carefully held on the inside, otherwise the seam is injured. The packing ring must be strong and carefully calked by the American method with a round nose calking-iron. The use of a piece of corrugated tube for fire-tubes of sufficiently large diameter.

Fig. 17.—Cracks in the rivet holes parallel to the edge of the plate in the longitudinal seams.

Location.—On the outer shell of boilers with large diameter. Also together with cracks extending from the rivet hole to the edge of the plate.

Cause.—Too weak single riveting with insufficient strength of the rivets and spacing; or the effect of the flames on exposed longitudinal seams.

Consequence.—Breaking of the plates, under certain conditions with explosion.

Prevention.—All longitudinal seams to be made with double riveting and, when possible, protected from the direct action of the flame. Caution in firing, emptying and filling the boiler. The emptying must be done after drawing the fire and under as small a pressure as possible. Quick cooling of the drum through filling of the boiler with cold water is to be avoided.

Fig. 18.—Cracks along the seams.

Location.—Beside the calked edge, especially at longitudinal seams.

Cause.—Cracking of the plate by hammering when insufficiently heated. Injury to the surface of the plate by bad calking. (Formation of a scratch in the surface.)

Consequence.—Dangerous at the longitudinal seams. Even the shortest crack, extending through the plate, necessitates its replacement.

Prevention.—The metal must not fall below a red heat when worked. Calking of the seams with a round iron is recommended.

Fig. 19.—Cracks in the plates.

Location.—Cracks in a circumferential direction on the fire-plates of externally fired boilers of every sort, mostly cross-cracks without any change of shape at the defective place.

Cause.—Sudden cooling of intensely heated plates by the cracking off of scale; cracks are then formed shortly after heating; want of elasticity in the material; often in mild steel plates.

Consequence.—Outflow of water under pressure; danger of breaking the whole plate. Branch-cracks in steel plates on the fire-side should not be neglected under any circumstances.

Prevention.—Thorough investigation of the plates. Use of the best material. Mild steel plates of too high tensile strength are to be avoided. Repairs with patches are not recommended. Replacing of the entire plate is preferable. Scratches in the material on the water-side should be examined with a file as to softness and depth. Hard plates with scratches are immediately to be renewed. Scratches on the fire-side of the plate are dangerous and quickly destroy the plate.

Fig. 20.—Cracks in corroded places on the inside of the boiler.

Cause.—Too thin through corrosion.

Consequence.—The sudden appearance of considerable leaks: by larger extension emptying of the boiler with explosive violence; very dangerous.

Remedy.—Furrow-shaped corrosions, especially on round seams and of large extent, are to be thoroughly investigated with punch or drill, and their depth to be measured. Repair by renewing the plate.

IV.—Faulty Material. Figs. 21 to 23.

Fig. 21.—Plates imperfect on the surface.

Location.—On any part of the drum-shell, as well on the inside as on the outside, but it is generally developed only on parts exposed to the fire.

Cause.—Unwelded material, due to cold-rolling or to penetration of surface scale during rolling.

Consequence.—The shell is only weakened by large extension or depth of the imperfection.

Prevention.—Only plates of the best quality should be used in boilers, especially for fire flues, and should be thoroughly inspected. Surface scales are to be carefully chiseled away over their whole extent and their depth determined.

Fig. 22.—Imperfections within the material. Open holes (forming of blisters).

Location.—On the fire-side. In all forms of boilers only on the worst heated plates (in or close to the furnace).

Cause.—Bad welding of the material through which uniform heating is hindered and unequal tensions produced, the larger holes appearing mostly in places where the temperature is very high.

Consequence.—Superheating on account of impeded transmission of heat. The defective place becomes red

hot. Considerable weakness in the plate. Burning of the plate on the fire-side. Very dangerous.

Prevention.—Thorough examination of plates before use by careful sounding. For correct sounding it is recommended to divide the plate into squares of 10 cm. (4 ins.) on a side. Imperfect plates are detected by the sound when rubbed on the surface with a stone.

Fig. 23.—Imperfections on the water-side of the tubes of water-tube boilers.

Cause.—Small imperfections owing to impure material.
Consequence.—Not dangerous.

THE STEEL RAIL POOL is dissolved, according to a press dispatch from Pittsburg, on Feb. 9, and prices of rails will now no doubt drop to the lowest figures ever known in the history of the trade. The rail pool has been in existence many years, and has been more successful in holding up prices than probably any other pool that has ever been known in the iron trade. It advanced the price of rails from $22 to $28 per ton between June and September, 1895, on a rising market for iron products in general, and then when the general market fell it continued to hold the price of rails at $28 for 15 months, or until December, 1896, when it reduced it to $25. It is now stated that the Lackawanna Steel Co. withdrew from the pool last week, giving as a reason that other members had cut the price below $25 per ton, and it at once began to seek orders at $20 per ton. The Lake Shore & Michigan Southern R. R. is said to have contracted with the Illinois Steel Co. for 5,000 tons of rails at $21 in Chicago, which is equal to $19 a ton in Pittsburg. How successful the steel rail mills have been in maintaining prices is shown by the following comparison of average annual prices of Bessemer pig iron, steel billets and steel rails since 1888. There has never been any pool of makers of pig iron, and none in steel billets, except the short-lived one which lasted for eight months in 1896, and then went to pieces, so that the prices of pig and of billets may be taken as normal prices in a free market, the difference between them representing approximately, except in 1896, the difference in cost, while the difference between the prices of billets and rails represents approximately the profits per ton which the steel rail men were enabled to make by reason of their pool:

Average Pittsburg Prices of Pig Iron, Billets and Rails.

Year.	Bessemer pig.	Steel—Billets.	Steel—Rails.	Difference between—Pig and billets.	Difference between—Pig and rails.	Difference between—Billets and rails.
1888.....	$17.38	$28.78	$29.83	$11.40	$12.45	$1.05
1889.....	18.00	29.45	29.25	11.45	11.25	.20
1890.....	18.85	30.32	31.75	11.47	12.90	1.43
1891.....	15.95	25.32	29.02	9.37	13.97	4.60
1892.....	14.37	23.63	30.00	9.26	15.63	6.37
1893.....	12.87	20.44	28.12	7.57	15.25	7.68
1894.....	11.38	16.58	24.00	5.20	12.62	7.42
1895.....	12.72	18.48	24.33	5.76	11.51	5.85
1896.....	12.09	19.33	27.75	7.24	15.66	8.42
Feb., 1897...	10.50	16.00	20.00	4.00	8.50	4.00

The average difference between rails and billets for the six years, 1891 to 1896, inclusive, was $6.72. The figures for the three years, 1888, 1889 and 1890, showed that rails could be sold at an average of less than a dollar a ton above the price of billets, leaving say $5.72 per ton as the average extra profit, which the pool enabled the steel rail men to make. As during these six years their sales were in the neighborhood of 7,500,000 tons, this represents a profit of $40,000,000.

If steel rails can be made almost as cheaply as steel billets, provided large orders are obtained for one size at a time, there would seem to be no reason why they cannot be sold at a profit at $17 per ton at Pittsburg, when the price of pig iron is $10.50. If they should fall to this price, it should encourage the railways to make extensive purchases, and give the stimulus to business of which the country now greatly stands in need.

THE EXHIBITION OF THE WORK OF GRADUATES of the Stevens Institute of Technology, Hoboken, N. J., which will be held on Feb. 19, as already announced in these columns, promises to be a most attractive feature of the 25th anniversary celebration of the Institute. The applications for space indicate that the exhibit will be a large one and most varied in character. One of the graduates, Mr. Lewis P. Nash, class of 1877, bears the distinction of being among the five most prolific inventors of the United States, over 200 patents having been issued to him on water meters, gas engines, and their various details. He will exhibit a complete electric light plant run by a gas engine. Much of the work of the graduates will be illustrated by photographs, working drawings, etc., of works carried out. The exhibition will be open to the public and will doubtless be largely attended by engineers.

A STEEL PLANT IS TO BE BUILT AT BIRMINGham, Ala., at last, according to a brief statement in the "Iron Age," which says that the capital will be $300,000, that the plant, therefore, will not be a large one, but "it will be ample to furnish more steel than the rolling mills want." If the wants of the rolling mills are to be the measure of the capacity of the new Southern steel works, we fear there is a poor outlook for it. The kind of steel works which the south needs is one which not only has its own rolling mills but its own plant for finishing its product into shape ready for final consumption. If it has to ship its partly finished material in the shape of ingots, blooms, etc., to other mills and plants to be finished it will probably find Pittsburg a most dangerous competitor.

THE LARGEST HYDRAULIC CYLINDER ever made in this country has recently been finished in the Homestead works of the Carnegie Steel Co. It was made for the large hydraulic press in the armor plate department. The original cylinder of the press, which had been made in England, was in three pieces, and when it broke it was decided to make a new one in one piece. Its dimensions are 11 ft. long and 6 ft. inside diameter, and its finished weight 80,000 lbs. It was made of nickel-steel in a sand moid, the heats of two open-hearth furnaces being required for the casting, which weighed 90 tons in the rough. It was bored in a machine specially built for the purpose, and when the boring was completed it is said that not a blowhole nor blemish was found in it.

THE NEW POST OFFICE AND FEDERAL BUILDING for Chicago will rest on concrete and steel cylinder foundations, according to information made public by the supervising architect, Mr. Henry Ives Cobb, of Chicago, Ill., under whose direction the plans are now being prepared in Washington, D. C. It is stated that the steel cylinders will vary in diameter from 12 ft. to 15 ft. and will be sunk to bed rock 72 ft. below the present surface and filled with concrete. The total estimated cost of the foundations is placed at $200,000, and it is announced that work will begin on them as soon as the ground is cleared from the old building, which is now in process of demolition. The total appropriation for the building is $4,000,000.

THE NEW BICYCLE FACTORY of the Keating Wheel Co., at Middletown, Conn., is interesting on account of its unique construction and of its method of application of motive power. The main building is a 2-story building, 1,000 ft. long and 50 ft. wide, and projecting from it at right angles are six separate shops, each 50 ft. wide, one of them 200 ft. long, two stories high, and the others about 100 ft. long, one story high. A separate building contains the offices, and another the power generating plant. Steam is generated by a 250-HP. Babcock & Wilcox boiler, and is utilized by a Greene cross-compound engine which drives by belt and countershaft a General Electric three-phase generator, known as an A-T 16-pole 250 KW, 450 revolution, 60 cycle machine. Another and similar three-phase generator, for furnishing power current, and a set of lighting machines will later be driven from the same countershaft. All the power is transmitted to the factory in the shape of electric current. The main shafts in the first floor of the main building are about 800 ft. long in all, being divided into three sections, between each of which is a 50-HP. General Electric induction motor suspended from the ceiling. Other lines of shafting in the various shops are driven by smaller motors. All of the motors are equipped with two pulleys on each end so that four independent shafts can be driven from each motor. The factory, when in running order, will be one of the most complete cycle factories in the world. It will be some months before it will be completely equipped with machinery. The company's 1897 wheels are being manufactured at Holyoke, and as soon as any piece of machinery can be dispensed with there it will be moved to Middletown.

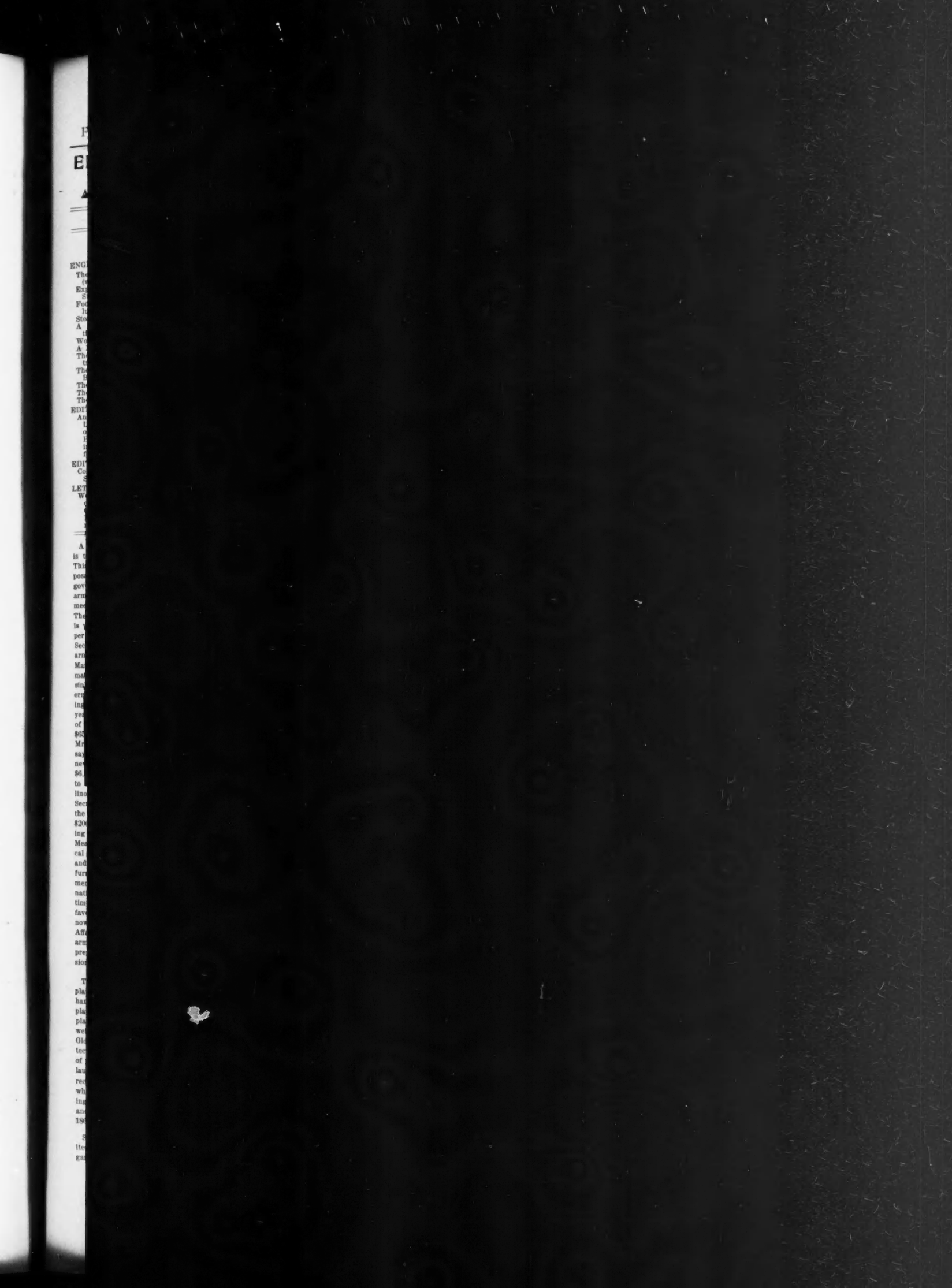
A GOOD ROADS BILL introduced in the New York Senate by Mr. Higbie provides for the appointment of a State Highway Commission, to consist of three members, to be confirmed by the Senate, one of whom shall be a civil engineer. They are to serve for three, four and five years, respectively. Each commissioner is to receive $5,000 annual salary, and the commission is to have $10,000 for office expenses annually. The commission is directed to compile statistics regarding the public highways throughout the state, and prepare a map indicating such highways as are of sufficient importance to be subject of state aid. The map must also show where material suitable for road-building may be obtained. The commission is to determine upon the best method of constructing roads, and advise county, city, town or village officers in relation to the matter. Half of the expense of road construction is to be a state charge and the other half a county charge in the first instance. Provision is made for assessing 35% of the expense on the county at large and 15% on the property directly benefited in certain cases. No county can receive more than 5% of the state appropriation in any one year. The State Commission may provide for roads in counties to connect roads already improved. This proposed law provides for the levying annually of a state tax of 1-10 mill, to be known as a state highway tax. The money thus raised is to pay the state's share of the expense of highway improvement. The tax provided in the bill would raise annually $436,000.

THE LEASE OF THE BRAZILIAN GOVERNMENT railways is advertised and bids will be received until May 15 at the General Traffic Department of the Ministry of Industry, Traffic and Public Works, Rio Janeiro, and also at the Brazilian Legations in Washington, London, Paris, Brussels and Berlin. The lease is to be for a term of 60 years. There are eight railways to be included in the lease, as follows: Brazil Central Ry., 755 miles; Bahia Ry., 151 miles; Sobral Ry., 134 miles; Pernambuco Southern Ry., 120 miles; Pernambuco Central Ry., 100 miles; Bahia & San Francisco Ry., 94 miles; Paulo Affonso Ry., 72 miles, and the Porto Alegre & Uruguayana Ry., 364 miles, or 1,790 miles in all.

COPPER SHEATHING FOR PASSENGER CARS is being tried on the New York, New Haven & Hartford R. R. at the suggestion of Mr. W. P. Appleyard, Master Car Builder. The improvement consists in covering with a thin sheet of copper each piece of wood sheathing, panelling, belt rail, etc., that enters into the construction of the exterior of the car, the wood being made thinner to compensate for the weight added by the copper. After the sheathings and other parts are covered they are applied to the body of the car in such a manner that the exposed surfaces are not punctured by nails. The cost of plating a car with copper is said to be less than painting and varnishing it, and a cheaper grade of lumber may be used than that now required. The copper takes a rich bronze tint, in the atmosphere, requiring no further treatment, and the finish is at once simple, beautiful and durable.

AN INTERESTING IMPROVEMENT IN GAS ENGINES has just been patented by Mr. Joseph Ledent, of Baltimore, Md., (Pat. No. 575,720, Jan. 26, 1897,) the object of which is to diminish the heat losses of the engine and increase its efficiency. As is well known in the ordinary gas engine 40 to 50% of the energy of the heat delivered to the engine is lost in heat carried away in the jacket water. Mr. Ledent proposes to substitute for the usual water jacket the injection of a small amount of water at each stroke of a vertical engine, when the piston is at its highest position, into an annular space formed by a groove in the upper portion of the barrel of the piston and the adjoining cylinder wall. When the explosion takes place part of this water will be evaporated into steam at high pressure, and part will remain as a film in the walls of the cylinder, preventing it from becoming overheated. The steam formed by the evaporation of the water does work as in a steam engine, this work representing so much gain from the fuel, as the heat required to evaporate it is heat which in the ordinary gas engine is wasted in the jacket water.

THE WORLD'S DRY-DOCKS NUMBER 622, of which England owns about 56%, with 266 located in England, Ireland and Scotland, and 74 located in England's colonies and dependencies. The other dry-docks are scattered through about 21 other nations. The United States has 63; France, 60; Germany, 32; Spain, 14; Holland, Italy and Sweden, 13 each, and Belgium 11. The Empress dock, at Southampton, is the largest single graving dock in the world; it is 751 ft. long, 88½ ft. wide, and 28½ ft. deep.

MEXICAN RAILWAYS IN 1896, says Mr. Romero in the "Bulletin of the American Geographical Society," aggregated nearly 7,000 miles in length. During 1895-96 Mexico exported precious metals worth $64,838,595; of which $51,071,661 went to the United States. Out of $40,178,306 in commodities exported, $28,580,034 in value went to the United States. But Mexico imported from the United States $20,145,763, out of $42,253,938 total value of imports.

THE STEVENS INSTITUTE OF TECHNOLOGY is an example of what a great amount of work can be done by an educational institution on a comparatively small endowment. The founder of the Institute, Mr. Edwin A. Stevens, in 1870 bequeathed a plot of ground and $150,000 for the erection of a building, together with $500,000 as an endowment fund. From this amount the U. S. government took $45,000 as a collateral inheritance tax, the law imposing such taxes being then in force as one of the "war taxes." As the number of students demanding admission to its courses increased, the Institute was badly hampered by the lack of funds to provide room, equipment and instructors for them. The President of the Institute, Dr. Henry Morton, several years ago presented $10,000 to the trustees with which to equip a new machine shop, and more recently has made other contributions to help increase the facilities. He has now made a new donation to the trustees of 1,000 shares of Texas Pacific R. R. Co. stock, worth to-day $10,000, but expected to increase in value in a few years, on account of the intrinsic value of the property it represents. This stock will be added to the fund started some years ago by the Alumni Association for the erection and maintenance of a new laboratory building, work upon which, it is hoped, will soon be begun. President Morton has succeeded in securing the following speakers for the anniversary dinner, which is to be held at the Waldorf on the evening of February 18: Bishop Potter, Andrew Carnegie, Professor James E. Denton, Governor Griggs of New Jersey, President Seth Low, Vice-president-elect Garret A. Hobart, C. F. Chandler, of Columbia, Mayor Strong, ex-Mayor Hewitt, Commodore Melville, U. S. N., and Mayor Fagan, of Hoboken.